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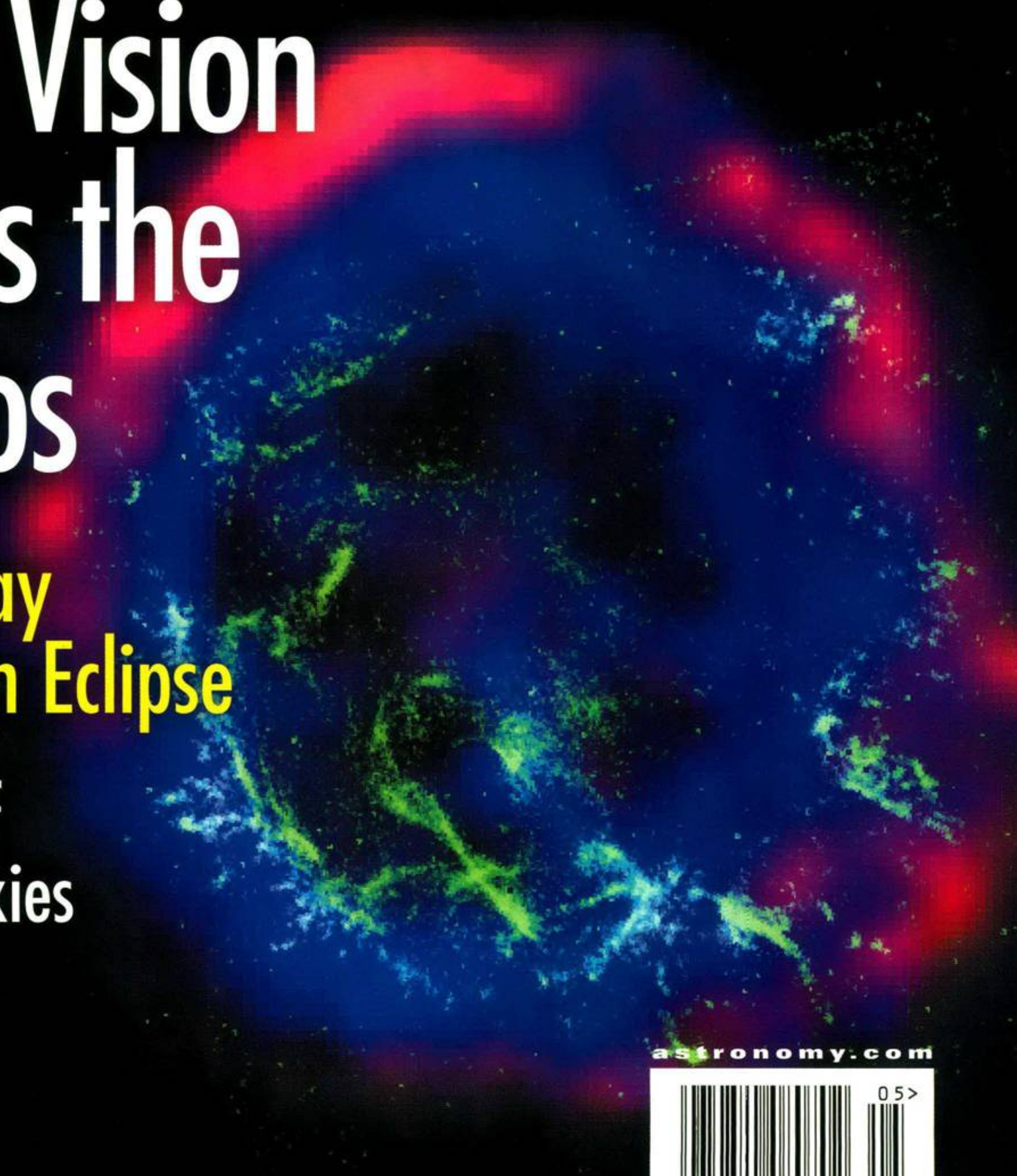

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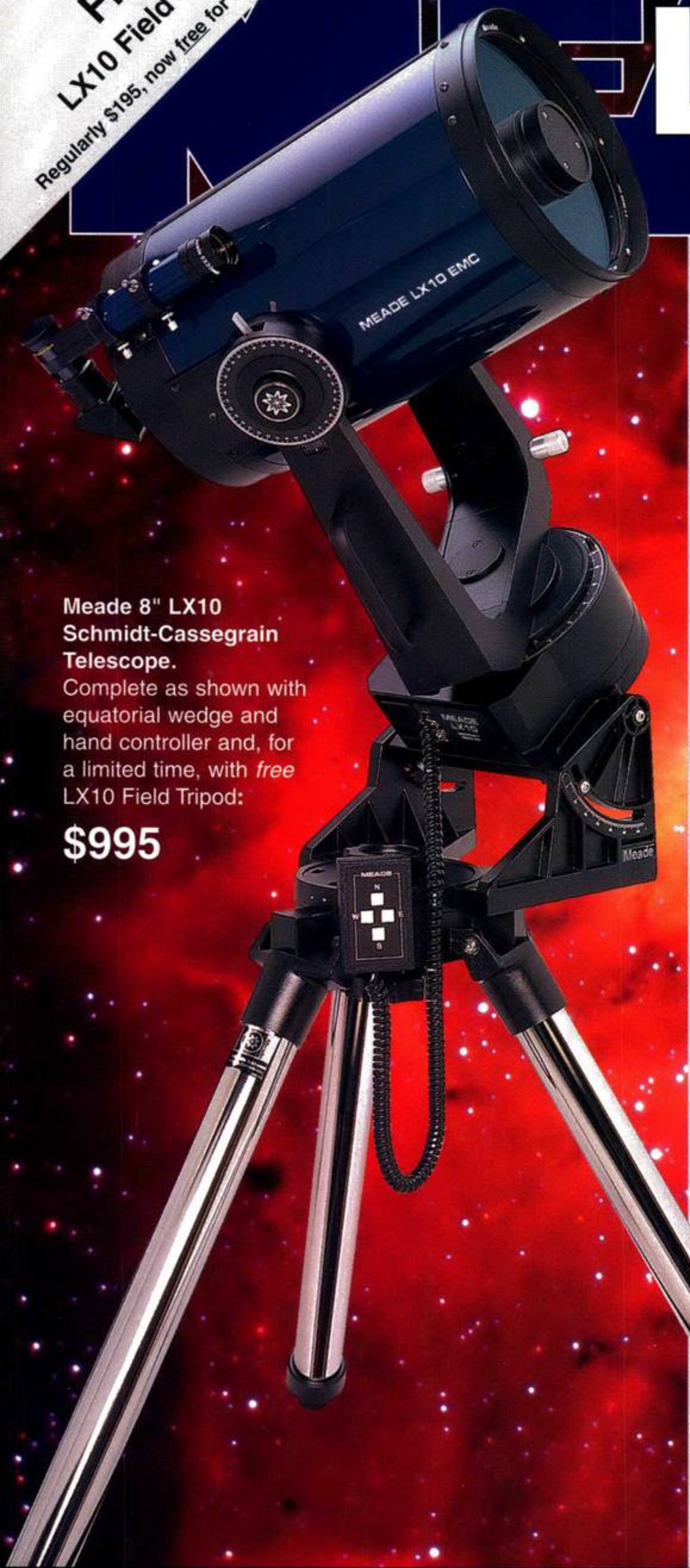
Regularly $195, now *free* for a limited time!

MEADE LX10



Meade 8" LX10 Schmidt-Cassegrain Telescope. Complete as shown with equatorial wedge and hand controller and, for a limited time, with *free* LX10 Field Tripod:

$995

Buy a Meade 8" LX10 Schmidt-Cassegrain telescope for $995 and, for a limited time, receive the $195 LX10 Field Tripod absolutely FREE!

For the serious amateur astronomer on a more limited budget, or for the more casual observer who nonetheless demands the very finest in optical performance, the Meade 8" LX10 satisfies every requirement. *Standard-equipment includes:*

Super-Multi-Coated Optical System: The *exact same* multi-coated 8" Schmidt-Cassegrain optical tube assembly as the more expensive Meade 8" LX200.

Series 4000 Super Plössl 26mm eyepiece: An $80 eyepiece, the SP26mm complements the exquisite imaging of Meade 8" Schmidt-Cassegrain optics.

Equatorial Fork Mounting: The relatively light weight, but very stable, LX10 fork mounting provides all of the rigidity required for sensitive high-power visual applications of the telescope, or for photographic or CCD imaging.

Cordless, DC-Powered Electronic Motor Drive: With electronically-regulated DC servo motor for automatic *sidereal-rate* tracking; powered for 50 hours by four AA-size batteries that fit conveniently into the telescope's control panel.

Worm-Gear System: The LX10's 5.75"-diameter worm gear produces extremely smooth, regular motion in R.A., with low periodic error — a periodic error that permits such advanced capabilities as long-exposure astrophotography or CCD imaging.

Hand Controller: Essential for micro-guiding the telescope in R.A. at 2x speed during long-exposure astrophotography. With the optional electric Declination motor *(see below)* added to the telescope, the hand controller is functional at 2x speeds on both telescope axes.

LX10 Field Tripod: The chromed steel LX10 Field Tripod provides an extremely rigid platform for visual and photographic observations with the telescope. Regularly $195, this tripod is included **free of charge** for a limited time with your purchase of the 8" LX10 telescope. *This free offer is valid from January 15, 2001 until further notice at participating dealers in the U.S.A.*

SPECIFICATIONS: 8" Model LX10 — Includes 8" Schmidt-Cassegrain optical tube assembly with EMC super multi-coatings (D = 203mm; F = 2000mm, f/10); fork mount with setting circles, manual slow-motion controls, and locks on both axes; 5.75" LX worm gear reduction system; sidereal-rate electronically-regulated DC servo motor drive; 4- pushbutton hand controller for 2x speed corrections in R.A.; battery compartment accepting four (user-supplied) AA-size batteries (telescope may also be powered from an auto cigarette lighter plug, using optional 25 ft. cord); 6 x 30mm viewfinder; eyepiece-holder and diagonal prism (1.25"); SP26mm multi-coated eyepiece; standard equatorial wedge with elevation scale, fine elevation control, and 360° azimuth orientation capability; LX10 Field Tripod (included only for a limited time, as noted above); complete operating instructions.

$995. (+ $65 packing & shipping in the 48 states)

Electric Declination Motor System for LX10. . . . . **95.**
#2014 Magellan I Telescope Computer System
for LX10 with 12,218-object database . . . . **375.**

Prices shown are suggested U.S. mail-order prices.

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MEADE LX200

The largest-selling serious telescopes in the world are now available at the most affordable prices *ever!*

With their large object databases, fast slewing speeds, and uncanny pointing precision, Meade LX200's are recommended for those amateurs who intend an extensive program of CCD imaging, astrophotography, or deep-space observing. Compare a Meade LX200 feature-for-feature with competing single-tine-fork, spur-gear-driven, GO TO Schmidt-Cassegrains:

Superb Optics: With oversize primary mirrors for greater full-field illumination, LX200 diffraction-limited imaging capabilities are a legend in the industry; we regularly receive reports stating that optical performance approaches that of a fine *ED* apochromatic lens.

Automatic GO TO Capability: Competing 8" Schmidt-Cassegrains claim to place objects "somewhere in the field of view"; Meade LX200's place objects **dead-center** in the field of view, first time, every time, to a pointing precision of **2 arc-minutes or better,** or, with Meade exclusive High Precision Pointing, to a precision of **one arc-minute or better.** *Meade LX200's are the only commercial telescopes ever manufactured that automatically GO TO any input R.A. and Dec., or to any object in the onboard database, to these levels of precision.*

Database of 64,359 Objects, a database *more than three times larger* than competing GO TO telescopes.

Permanently-Programmable Smart Drive™ routinely achieves 5 arc-sec. periodic error, an observatory standard. Other brands of GO TO 8" SCT's decline to state their periodic error and do not offer any programmable error-corrector.

9-Speed Dual-Axis Electronics: Electronics that cover every contingency of telescope positioning — from 2x photo-guide, to 32x image centering, to 8°/sec. slewing across the sky, plus 6 other dual-axis drive speeds in between.

Rigid LX200 Dual-Tine Fork Mountings with Dual 5.75" Worm Gears are the choice of advanced observers, CCD imagers, and astrophotographers for their most sensitive applications. Competing spur-gear-driven single-tine forks can not approach the strength, rigidity, and drive-rate precision built into every Meade LX200 mounting.

Full Long-Exposure Capability: Competing 8" GO TO telescopes describe their capability to take short-exposure "planetary and terrestrial photos," without reference to any long-exposure capabilities. Meade LX200's have been the instruments of choice in **thousands** of the most detailed long-exposure images ever taken by amateur astronomers.

Strong Field Tripods: Unlike the thin, extruded aluminum tripods of competing models, every LX200 includes a fully adjustable steel field tripod perfectly suited to the sub-arc-second resolution of the telescope's optics.

SPECIFICATIONS: 7", 8", 10", and 12" LX200's — Each complete telescope includes 8" or 10" (f/6.3 or f/10) or 12" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and multi-function control panel; manual and electric slow-motion controls on both axes; keypad hand controller with digital readout display, permanently programmable Smart Drive, 9-speed drive controls on both axes (7-speed on 12"), High-Precision Pointing, and GO TO controller; 64,359-object onboard celestial software library; 25 ft. power cord and adapter for telescope operation from 115v.AC (optional #1812 Electronic DC Adapter allows for field powering directly from an automobile cigarette lighter plug); 8 x 50mm viewfinder; 1.25" diagonal prism (7", 8", 10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (7", 8", 10") or giant field tripod (12"); operating instructions.

8" LX200 Schmidt-Cassegrain	**$2295**
10" LX200 Schmidt-Cassegrain	**2695**
12" LX200 Schmidt-Cassegrain	**3995**
7" LX200 Maksutov-Cassegrain	**2795**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 12"—$215; 7"—$125.

Prices shown are suggested U.S. mail-order retail prices.

MEADE LX200 EMC
MEADE LX200
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Meade 8" LX200 Schmidt-Cassegrain Telescope. Complete as shown:

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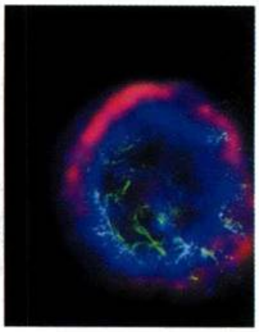

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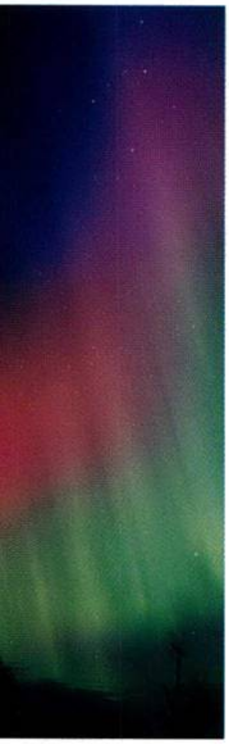

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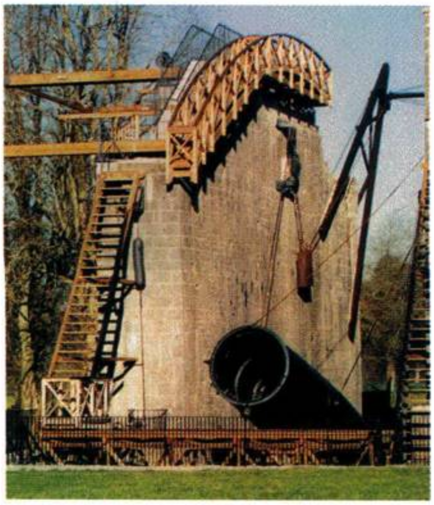

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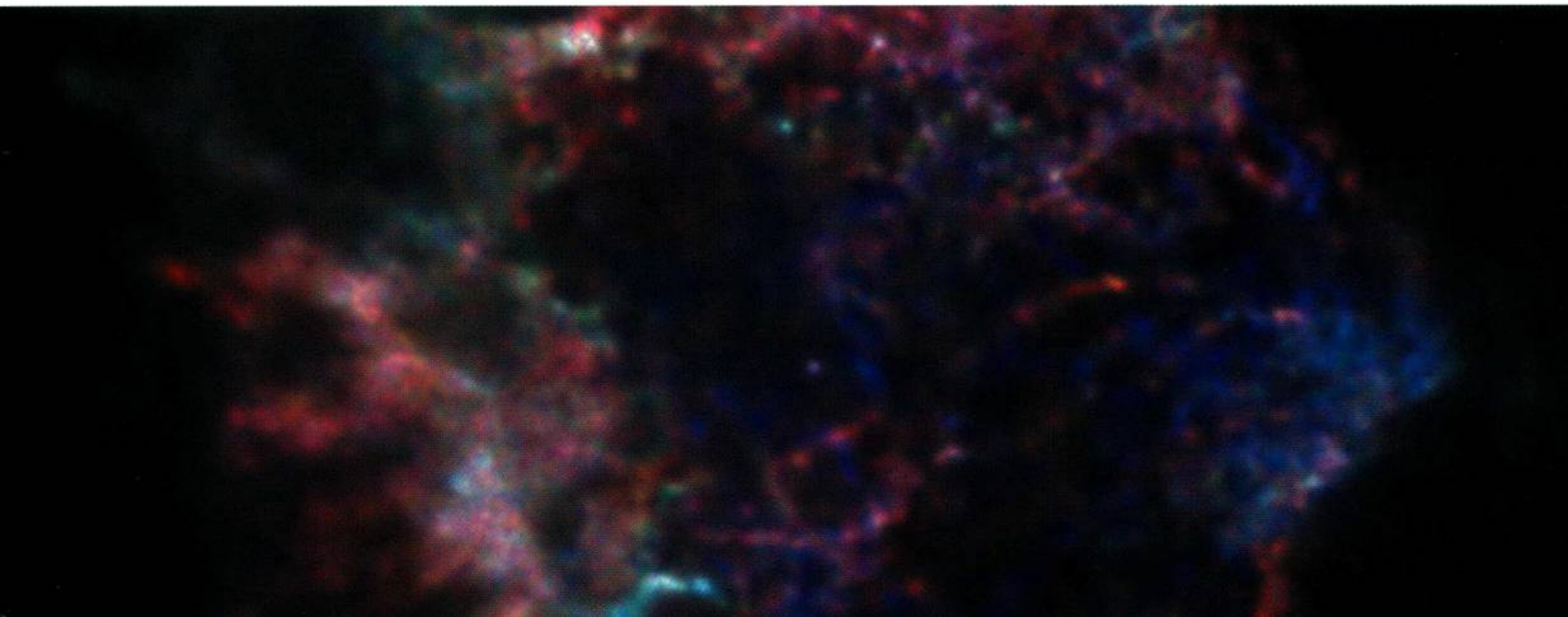

BEHIND THE SCENES

BY BONNIE BILYEU GORDON

Changing Status

People have been asking all week how I feel about Pluto being downsized. The first time I heard the question, I stared back blankly, thinking I'd missed a good story. Soon I learned that New York's Hayden Planetarium, part of the Museum of Natural History, announced recently that it has changed its own designation of Pluto from a planet to a planetesimal. The story was carried on the front page of *The New York Times* and even in the *Milwaukee Journal Sentinel.*

Chuck Braasch

Many people are taking the Hayden proclamation quite seriously. Some of Pluto's biggest fans show signs of distress thinking of the planet as just another asteroid, albeit a big one. Well, do not fret. The Hayden doesn't get to make this decision, at least not for anybody outside its walls.

Planet and asteroid designations fall to Brian Marsden and his colleagues at the International Astronomical Union's Minor Planet Center at the Harvard-Smithsonian Center for Astrophysics. Brian himself has given the matter a good deal of consideration, but he hasn't yet convinced the officials of the IAU to change Pluto's status.

Status continues, however, to change here at *Astronomy*; we have a new designer, Chuck Braasch, who comes to us from Kalmbach Publishing's ad services art department. Chuck is a Wisconsin native who has recently moved to Milwaukee. He trained in design at the Madison Area Technical College, and like many other *Astronomy* staffers, has a passion for books, music, dogs and toys.

Chuck replaces our former assistant art director Thomas Ford, who was promoted to become the art director of Kalmbach's growing Dot.com division. While checking out Tom's work at Astronomy.com, you might want to look at recent astronomy news online and additional features that complement other magazine stories.

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Meade® Starfinder 8" Equatorial with Motor Drive... *now only* ***$599!***

Complete with giant rack-and-pinion focuser for 1.25" and 2" eyepieces, 6 x 30mm viewfinder, Super Plössl 26mm eyepiece, and premium-grade Pyrex® optical system.

Precision, heavy-duty equatorial mount with DC-powered drive system for fully automatic tracking.

Shown with optional #2011 Magellan I Computer System.

Professional-Grade Optical System: Hand-figured, parabolic primary mirror and elliptical flat secondary, both of Grade-A Pyrex glass. Optics are multi-coated and meet the theoretical limits of resolution.

Accessories and Components: Premium-grade multi-coated SP26mm eyepiece (1.25"); 6 x 30mm viewfinder with wide 7° field; strong, durable, spiral-wound optical tube with attractive white finish.

Precision Equatorial Mount: Manufactured of machined aluminum to tolerances of .001" or better, with 4"-dia. pier and die-cast tripod legs for rock-solid support of the optical tube. Moves effortlessly from object to object on precision bearing surfaces. Polar and Dec. shafts are 1" solid steel. Setting circles on both axes.

Battery-Powered Cordless Drive System: For fully automatic tracking of celestial objects. Operates over 50 hours from 6 (user-supplied) AA-batteries or from 12v. auto cigarette lighter plug, using optional 25 ft. cord.

2" Giant Focuser: Meade #77 giant rack-and-pinion focuser is included as standard equipment, with eyepiece-holders for both 1.25" and 2" eyepieces.

Starfinder Equatorial 16: Includes equatorial mounting with 1.5" steel shafts, Sealmaster ball bearings, 6" dia. pier, and 6 x AA-size battery-powered worm gear drive; 8 x 50mm viewfinder; #77 giant focuser.

Magellan I Telescope Computer System: Use the Magellan I computer to manually slew the telescope quickly to any of 12,218 database objects, or to any object of known R.A. and Dec. Specifications and object database are identical to Magellan I for Starfinder Dobsonians *(see facing page)*.

#2011: for Meade Starfinder Equatorial 6", 8", or 10" . . . . . $295.
#2012: for Meade Starfinder Equatorial 16". . . . . 295.

Magellan II Computer-Corrector: Plug the Magellan II into the control panel of your Meade Starfinder Equatorial and you have all the capabilities of the Magellan I, above, including 12,218-object database, *plus* a 4-speed (2x, 8x, 16x, 32x), dual-axis, drive corrector/microslewing system.

#2018: for Starfinder Equatorial 6", 8", 10" . . . . 495.
#2019: for Starfinder Equatorial 16" . . . . 595.

Packing & shipping in the 48 states: Magellan I – $15, Magellan II – $20.

Special Eyepiece Offer! At the time you order any Meade Starfinder Equatorial telescope, you can buy a Meade Series 4000 Super Plössl 9.7mm eyepiece ***for only $29.95!*** *Purchased separately, the SP9.7mm eyepiece sells for $79.95.*

Meade Starfinder Equatorial Telescopes

6" f/8	**$499**	**10" f/4.5**	**699**
8" f/6	**599**	**16" f/4.5**	**2695**

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Regularly $99, now *free* for a limited time

Now you can join the ETX revolution for as little as $299, complete!

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ETX-60AT · ETX-70AT

Let Meade high-resolution ETX optics and standard-equipment Autostar controller take you on an automated guided tour of the Solar System, the Galaxy, and beyond.

Fork Mount with Dual-Axis Drive System: Precision worm gear systems permit smooth pushbutton motions of the telescope, as well as sidereal-rate tracking in the altazimuth mode.

Free #882 Field Tripod!

For a limited time you can purchase a Meade ETX-60AT or ETX-70AT Astro Telescope and receive a full-length Meade #882 Standard Field Tripod (regularly $99), **absolutely free.** The #882 Tripod is ideal for either seated or standing observations through the telescope. *This offer is valid from January 15, 2001, until further notice, at participating Meade dealers in the U.S.A.*

Standard-Equipment #494 Autostar™ Controller: Includes most of the same features as the more advanced #497 Autostar available for larger ETX models *(facing page)*.

- **Automatic dual-axis GO TO function at 4.5°/sec.** to any of more than 1450 database objects, including the complete Messier and Caldwell deep-space object catalogs, the major planets from Mercury to Neptune, 26 asteroids, 15 periodic comets, and more. Or GO TO *any* object of known R.A. and Dec.
- **9-speed Dual-Axis Operation:** Push-button control of the telescope on both axes, simultaneously, at any speed from 2x sidereal to 4.5°/sec., plus sidereal-rate tracking.

High-Resolution Achromatic Objective Lenses of exclusive Meade design; each lens yields razor-sharp images of astronomical and terrestrial subjects.

Flip-Mirror System: Flip the internal optical flat mirror "up" for 90° observing; flip the mirror "down" for terrestrial observing with the optional #933 45° Erecting Prism or for photography with the optional #64ST Photo Adapter.

Cordless Operation: The dual-axis drive operates for over 20 hours in the field from six AA-size (user-supplied) batteries which store neatly inside the drive base.

Solar System: Saturn
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AUTOSTAR
Guided Tour Tonight's Best
ENTER
MODE
GO TO
SPEED
MEADE
AUTOSTAR
MEADE
COMPUTER CONTROL
OFF
AUX

ETX-70AT: $349, complete with #494 Autostar Controller and #882 Standard Field Tripod

ETX-60AT: $299, complete with #494 Autostar Controller and #882 Standard Field Tripod

SPECIFICATIONS: ETX-60AT and ETX-70AT Astro Telescopes — Each includes achromatic refractor optical tube assembly (D = 60mm, F = 350mm, f/5.8 *or* D = 70mm, F = 350mm, f/5) with multi-layer optical coatings; internal flip-mirror system for either straight-through or 90° observing position; fork mount with electric slow-motion controls, setting circles, and locks on both axes; electronic control panel; 9-speed (2x sidereal through 4.5°/sec.) dual-axis motor drive system with #494 Autostar computer controller; sidereal-rate tracking; internal compartment accepting six (user-supplied) AA-size batteries; MA9mm (39X) and MA25mm (14X) multi-coated eyepieces; #882 Standard Field Tripod (included only for a limited time, as noted above); operating instructions. **ETX-60AT — $299** (+$10 packing & shipping in the 48 states); **ETX-70AT — $349** (+$10 P & S).

OPTIONAL SYSTEMS FOR MEADE ETX TELESCOPES*

#882 Standard Field Tripod (60, 70)	$99.00
#827 8 x 25mm Right-Angle Viewfinder (60, 70)	49.95
#773 Hard Carry Case (60, 70)	59.95
#933 45° Erecting Prism (60, 70)	49.95
#64ST Photo Adapter (60, 70)	19.95
#497 Autostar Computer Controller (90, 125)	149.00
#880 Equatorial Table Tripod (90)	29.95
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#774 Hard Carry Case (90)	99.95
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#932 45° Erecting Prism (90, 125)	49.95
#64 Photo Adapter (90, 125)	34.95
Electric Focuser #1244 (90) *or* #1247 (125)	119.95

**see also the Meade accessory ad in this issue.*

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FOCUS
SPEED
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ETX-90EC: $495, complete with Electronic Controller

ETX-125EC: $895, complete with Electronic Controller

Save up to $150!
ETX-90EC now $495
Autostar $99 for a limited time!

Meade® 3.5" and 5" ETX® models include the very latest in microprocessor-controlled capability:

Fork Mount with Dual-Axis Drive System: Each with high-torque DC motors on both telescope axes, permitting electronic operation from the standard-equipment plug-in hand controller.

Pushbutton Electronic Hand Controller: Use any of four dual-axis speeds: 8x for image centering at high power; 32x for image centering at lower power; 0.75°/sec for image centering in the viewfinder or for terrestrial tracking; 5°/sec for fast slewing across the sky.

Maksutov-Cassegrain Optical Systems: Manufactured at the Meade Irvine, facility, ETX diffraction-limited optics produce images so high in contrast and resolution that ETX telescopes often outperform other telescopes of larger apertures.

Flip-Mirror System: Flip the internal optical flat mirror "up" for 90° observing; flip the mirror "down" for terrestrial observing with the optional #932 45° Erecting Prism or for photography with the optional #64 Photo Adapter.

Cordless Operation: The dual-axis drive system operates for more than 40 hours from eight (user-supplied) AA batteries which store neatly inside the drive base.

Special Offer: ETX-90EC now $495!

Now for a limited time you can purchase the Meade ETX-90EC Astro Telescope — the largest-selling modern telescope in the world — at $495, a savings of $100 off the regular price. *This offer is valid from January 15, 2001, until further notice, at participating Meade dealers in the U.S.A.*

Optional #497 Autostar™ Now Only $99 (regularly $149) For a Limited Time! Plug in the optional Meade #497 Autostar computer controller for LX200-type operation, including:

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MEADE
ENTER
MODE
GO TO

- **Automatic dual-axis GO TO function at 5°/sec** to any of more than 14,000 database objects, including thousands of deep-space objects; the 8 major planets from Mercury to Pluto; 26 of the brightest asteroids; 15 periodic comets; and more.
- Select any of Autostar's database objects, or any object of known R.A. and Dec, press ***GO TO*** and the telescope automatically slews to the object.
- **9-Speed Dual-Axis Operation:** Pushbutton control of the telescope on both axes, simultaneously, at any speed from 2x sidereal to 5°/sec., plus sidereal-rate tracking.

SPECIFICATIONS: ETX 90EC and ETX-125EC Astro Telescopes — Each includes Maksutov-Cassegrain optical tube assembly (D = 90mm, F = 1250mm, f/13.8 *or* D = 127mm, F = 1900mm, f/15) with EMC super multi-coatings; internal flip-mirror system for either straight-through or 90° observing position; fork mount with electric slow-motion controls, setting circles and locks on both axes; electronic control panel; 4-speed (8x, 32x, 0.75°/sec, 5°/sec) dual-axis motor drive system with hand controller; sidereal-rate tracking in equatorial mode with optional table tripod or deluxe field tripod; internal battery compartment accepting eight (user-supplied) AA-size batteries; 8 x 21mm erect-image (ETX-90EC) *or* 8 x 25mm right-angle (ETX-125EC) viewfinder; Series 4000 Super Plössl 26mm eyepiece (1.25"); instructions. **ETX-90EC — $495** (+ $20 packing & shipping in the 48 states); **ETX-125EC — $895** (+ $30 P & S).

AUTHORIZED U.S. AND CANADA MAIL-ORDER DEALERS

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MEADE

RESEARCH-GRADE ACCESSORIES

Series 4000™ Super Plössls 52° field; multi-coated

Meade 4-element Super Plössls, updated and redesigned to utilize the latest in optical glass-types, are the finest general-purpose eyepieces available. For observing hairline lunar and planetary detail, splitting close doubles, or for deep-space; guaranteed to deliver more contrast and image sharpness than any other brand. Rubber eyeguards fold down for eyeglass wearers–a feature not available on competing brands. Multi-coated. All focal lengths through 32mm are parfocal.

Super Plössls (SP; 4-elements; 1.25"; 52°):

6.4, 9.7, 12.4, 15, 20, 26mm	each:	**$79.95** (4.54)
32mm (52°); **40mm** (44°)	each:	**99.95** (5.26)
56mm (52°; 2")		**199.95** (7.02)

Series 4000™ 2x Apochromatic Barlow Lens

#140: The most advanced Barlow lens available for commercial telescopes, the Meade #140 includes 3-element, multi-coated, air-spaced optics. Doubles the power of any eyepiece with which it is used and yields images absolutely unmatched in resolution, contrast and color correction. The #140 optically complements any telescope — refractor, reflector, or Schmidt-Cassegrain. Accepts 1.25" eyepieces. Mechanical components are of machined aluminum and brass. Lens diameter is 28mm; clear aperture 26mm.

$79.95 (5.26)

Series 4000™ Super Wide Angle 67° field; multi-coated

For exquisite wide-angle images at low-to-medium powers, with pinpoint edge-of-field resolution. Ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8mm, 18mm, and 24.5mm are superb complements to the #140 Barlow, above.

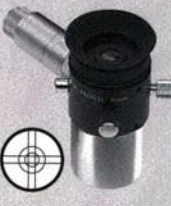
Super Wide Angle (SWA; 6-elements; 1.25"; 67°)–**13.8mm: $139.95** (4.54); **18mm: 149.95** (4.54); **24.5mm: 179.95** (5.26); **32mm** (2"): **239.95** (7.02); **40mm** (2"): **299.95** (7.02)

Series 4000™ Ultra Wide Angle 84° field; multi-coated

The ultimate eyepieces; extreme image sharpness over an amazing 84° field. A perfect optical match with Schmidt-Cassegrains and fast Newtonians.

Ultra Wide Angle (UWA; 8-elements; 1.25"; 84°)– **4.7mm: $169.95** (5.26); **6.7mm: 199.95** (5.26); **8.8mm** (1.25"/2"): **239.95** (7.02); **14mm** (1.25"/2"): **299.95** (7.02)

World's Most Advanced Illuminated Reticle Eyepiece



Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Multi-coated optics. **Internal batteries included.** Bullseye reticle. 1.25".

$149.95 (6.14)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator.

$129.95 (5.26)

Series 3000™ Plössls 50° field; multi-coated

Meade Series 3000 Plössls yield the finest image corrections obtainable from the classical 4-element Plössl design. Focal lengths from 5mm through 25mm are parfocal, so that, at most, only slight refocusing of the image is necessary from eyepiece to eyepiece. Unlike competing moderately-priced Plössls, Meade Series 3000's are **multi-coated** for maximum light transmission and image contrast. Chrome-plated brass barrels are threaded for standard filters. All eyepieces are fitted with fold-down rubber eyecups for comfortable observing. The PL40mm *(far right in photo)*, an excellent complement to any ocular set, produces spectacular low-power, wide fields, ideal for scanning the Milky Way. Manufactured exclusively to Meade optical designs, Series 3000 Plössls yield fine, high-resolution results on reflectors, refractors, and Schmidt-Cassegrains of any focal ratio.

Series 3000 Plössls (4-elements; 1.25"; 50°)

5, 6.7, 9.5, 16, 25mm each: **$49.95** (3.86); **40mm** (44° field): **$79.95** (3.86)

Series 4000™ f/6.3 Focal Reducer/ Field Flattener

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5° at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture.

$129.95 (5.26)

Series 4000 Photo-Visual Color Filters (1.25")–Premium filters, made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue

each **$14.95** (2.73)

Set #1–4 filters: #12, #23A, #58, #80A	**49.95** (4.54)
Set #2–4 filters: #11, #25A, #47, #82A	**49.95** (4.54)
Set #3–4 filters: #8, #21, #38A, #56	**49.95** (4.54)

Series 4000 Moon Filter (#ND96): Reduces glare and irradiation during lunar observing. 13% uniform light transmission across the visual spectrum. Threads into 1.25" barrels. **$16.95** (2.73)

#911B
#910B
#908B
#911N
#910N
#908N

Series 4000 Nebular Filters—Premium multi-layer interference filters, the finest obtainable. Use broadband ("B") filters to block most forms of light pollution; use narrowband ("N") filters in heavily light-polluted areas or for extremely high-contrast observing of faint nebulae.

#908B–Threads into 1.25" eyepieces, 26mm dia.	**79.95** (4.54)
#910B–Threads into 2" eyepieces, 44mm dia.	**119.95** (5.26)
#911B–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**99.95** (5.26)
#908N–Threads into 1.25" eyepieces, 26mm dia.	**89.95** (4.54)
#910N–Threads into 2" eyepieces, 44mm dia.	**129.95** (5.26)
#911N–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**119.95** (5.26)

#911X
#910X
#908X

Series 4000 Oxygen-III Filters Observe diffuse emission and planetary nebulae as you never thought possible! Exclusive Meade *60-layer* interference coating technology isolates the 496nm and 501nm O-III lines to tremendously enhance observable nebular structural detail in all telescopes.

#908X–Threads into 1.25" eyepieces, 26mm dia.	**99.95** (4.54)
#910X–Threads into 2" eyepieces, 44mm dia.	**159.95** (5.26)
#911X–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**149.95** (5.26)

2x Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25"

$47.95 (4.54)

#905 Variable Polarizer (1.25")

For glare reduction in observing the Moon. Includes two Polarizer filters mounted in a machined cell and permits continuously variable light transmission from 5% to 25%, to compensate for varying lunar surface brightness according to the Moon's phase and the aperture of the telescope. Accepts 1.25" eyepieces. **$49.95** (5.26)

2x Short-Focus Barlow (1.25")

#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of the #122, above. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated.

$47.95 (4.54)

Electric Focusers for SCT's

For extremely smooth microfocusing of the image. Does not affect use of the manual coarse-focus knob.

#1206 Electric Focuser: Plugs into control panel of Meade 8", 10", 12" LX200 models and operates from LX200 hand controller. **$149.95** (7.48)

#1205 Electric Focuser: For **all** other Meade 8", 10", 12" SCT models; includes separate hand controller; accepts one self-contained (user-supplied) 9v. battery.

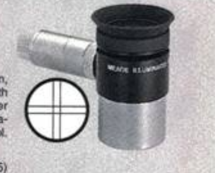
$169.95 (7.88)

Modified Achromatic Eyepieces

Meade 3-element MA eyepieces yield sharp, well-corrected images on the Moon, planets, and deep-space at a reasonable price. Multi-coated; threaded for filters; 1.25" barrel diameter. Apparent field: 40°. **MA 9, 12, 25, 40mm.**

each: **$37.95** (4.54)

MA12mm Illuminated Reticle Eyepiece



Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle; rubber eyecup. Wireless red LED illuminator and variable brightness control. 1.25". **Batteries included.**

$99.95 (3.45)

As above but with 6 ft. cord and plug for Meade telescopes with power panels, in place of wireless illuminator. **$79.95** (5.26)

2x-3x Variable Barlow (1.25")

#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25".

$59.95 (4.54)

2" Diagonal Mirror

#929: Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes multi-coated precision optical flat made at the Meade factory; with 1.25" eyepiece adapter. **#930:** Same as #929 but with 2" barrel to fit into focusers with 2" eyepiece-holders.

#929 or **#930,** each: **$99.95** (6.85)

#777 Off-Axis Guider for SCT's

Internal prism diverts light for monitoring telescopic image during long-exposure astrophotography. Threads to any Meade or Celestron rear cell. Use with illuminated reticle eyepiece and T-Mount for your 35mm camera.

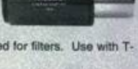
$79.95 (6.85)

45° Erecting Prisms

Fully coated roof prisms to invert the astronomical image in Schmidt-Cassegrains or refractors during terrestrial observations, while presenting a convenient 45° observing angle. Specify **#927** (.965"), **#928** (1.25"), or **#931** (fits .965" focuser, accepts 1.25" eyepieces).

$42.95 (3.86)

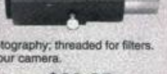
Camera Adapters



Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

.965": **$27.95**; 1.25": **$29.95** (3.86)

Variable-Projection Camera Adapter (1.25")



Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-mount for your camera.

$39.95 (3.86)

Variable Tele-Extender

For eyepiece-projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Sliding cell with lock permits wide range of projection magnifications with the same eyepiece. Use with T-mount for your camera.

$39.95 (3.86)

T-Adapters for SCT's

Rigidly couples camera to telescope for prime focus photography with any Meade or Celestron Schmidt-Cassegrain. Use with T-Mount for your 35mm camera.

$26.95 (3.86)

CCD-Photo-Visual Flip-Mirror Systems

An essential accessory for imaging with ***any*** brand of CCD imager or for astrophotography with a 35mm camera. Flip mirror "down" to center the image while viewing with an eyepiece at 90°; flip mirror "up" to pass light on to CCD chip or 35mm camera film plane. Each unit includes: precision optical-flat Pyrex® mirror; 2-axis mirror-adjustment screws and locks for precise image centering; extra-fine helicoid focusing of the eyepiece; extension tubes for attaching either 35mm camera (using T-Mount) or CCD imager (using either T-threads or 1.25" barrel). Threads to rear cells of all Schmidt-Cassegrain telescopes; may remain on telescope and used in place of diagonal prism for visual observing as well.

"Over the past 10 years I have used all manner of flip-mirrors. The Meade Flip-Mirror Systems are absolutely the best—rock solid, high-precision, beautifully manufactured; they virtually eliminate all flexture between the CCD and telescope." — Jack Newton

#644 Flip-Mirror System: Accepts any 1.25" eyepiece. Mirror clear aperture: 22mm. Use with CCD's up to Pictor 416XT or ST-7, or smaller; or visual observing with 1.25" eyepieces. **$149.95** (7.02)

#647 Flip-Mirror System: Accepts either 1.25" or 2" eyepieces. Mirror clear aperture: 40mm. Recommended for full-field 35mm astrophotography or with CCD's of any size, including all Meade Pictor Series through 1616XT, as well as ST-4 through ST-8; or for visual applications with 1.25" or 2" eyepieces. **249.95** (8.49)

#157 1.25" Adapter: Permits use of either Flip-Mirror on telescopes with 1.25" eyepiece-holders. (Requires approx. 2" additional focus travel with #644, 3" with #647.) **15.00** (3.86)

#644

#647
MEADE
FLIP-MIRROR SYSTEM

Epoch 2000® Sky Software

The most powerful astronomical software ever made available can now be yours for only $149!

Epoch 2000sk *(upper display at left)*: Now you can use the most advanced, most precise full-color sky software ever created, to zoom-in on telescopic fields **smaller than one arc second!** With star positions displayed as precisely as **0.01 arc second,** the Trapezium in Orion is no longer shown as a single point, as in other software, **but as four precisely oriented starpoints, just as they appear in the telescope.** No longer do you need to guess the R.A. and Dec. of an object located away from the field center, as in other programs: Epoch 2000sk dynamically reads out the R.A. and Dec. of the cursor position anywhere in the field **and updates R.A. and Dec. instantaneously as the cursor is moved about the field.** Meade LX200 owners can use Epoch 2000sk for remote auto-centering of objects in the telescopic field **to a precision of 30 arc seconds,** routinely!

Print professional-quality star charts in either black-and-white or color, at any zoom setting or sky scale between 180° and one arc second, with your own customized borders, headers, footers, margins, fonts, colors, and grids.

Epoch 2000ip Image Processing Software *(lower display at left)*: Epoch 2000ip makes it easy to enhance and analyze your CCD images with the same sophisticated techniques used by professional astronomers to uncover hidden structure in a spiral galaxy or obscure detail on the surface of a planet. This powerful software includes virtually every technique available for image enhancement. Techniques that bring out detail totally invisible in your original image, transforming it from the ordinary to the spectacular.

EPOCH 2000sk Sky Software: 281,000 objects supplied on 3.5" discs for Windows 3.1 or higher; fully compatible with Windows 95 . . . . **$149**

EPOCH 2000sk-CD Sky Software: 19 million objects, including the complete Hubble Guide Star Catalog; supplied on CD-ROM **179**

LX200 Interface Cable: for Meade LX200 operation by Epoch 2000sk **25**

EPOCH 2000ip Image Processing Software: Supplied on 3.5" discs for Windows 3.1 or higher; fully compatible with Windows 95 . . . . **$199**

Series 4000™ f/3.3 CCD Focal Reducer/Field Flattener

f/3.3 CCD FOCAL REDUCER

NEW!

Revolutionary 3-element Meade design permits ultrafast CCD imaging with **increased** edge-of-field resolution and color correction! Reduces CCD exposure times by up to 80%. Threads on to the rear cell of any Meade or Celestron Schmidt-Cassegrain. Converts f/10 Schmidt-Cassegrain telescopes to **f/3.3** and f/6.3 SCT's to **f/2.** Variable T-Adapter (included) allows range of f/ratios between f/3 and f/5 on f/10 SCT's and between f/1.9 and f/3.2 on f/6.3 SCT's. Use with CCD imagers of any brand and chip dimensions. Not for visual or photographic applications. Multi-coated; 41mm clear aperture. **$149.95** (5.26)

Plössl 25mm Illuminated Reticle CCD Framing Ocular

NEW!
MEADE
PLÖSSL
CCD FRAMING

Displays rectangular frames of all popular CCD chip sizes, including all Meade Pictor models and ST-4 through ST-8. Shows precisely the image size and orientation that appear on CCD chip. Insert directly into telescope eyepiece-holder, or use with Flip-Mirror *(above)*. Includes 4-element coated Plössl optics; lockable spacer ring to fix focus position; rubber eyecup; variable LED illumination control; batteries. 1.25". **$129.95** (4.54)

#825 8 x 25mm Right-Angle Viewfinder for ETX-90

Permits comfortable right-angle viewing. Replaces standard-equipment finder on 90mm ETX models, using the same bracket. Wide-angle, achromatic, coated optics; actual field 7.5°. Precise helicoid focusing. **$49.95** (4.26)

#64 T-Adapter for ETX®

Threads to the photo port of all ETX-90 and ETX-125 models. Rigidly couples any 35mm camera with removable lens to the telescope for lunar, planetary, or terrestrial photography. Includes extension tube for longer effective focal length, if desired. Use with T-Mount for your 35mm camera. **$34.95** (3.86)

MA12mm Illuminated Reticle Astrometric Eyepiece

NEW!
MEADE
ASTROMETRIC
ILLUMINATED

A high-precision eyepiece for a wide range of astronomical measurements. Includes four red-illuminated, laser-etched scales for measuring double star angular separations, position angles, planetary diameters, and lunar crater diameters, and for long-exposure photo-guiding. Modified Achromatic 3-element coated optics; diopter adjustment; rubber eyecup; variable LED illumination control; batteries. 1.25". **$119.95** (4.26)

Series 4000™ 8mm – 24mm Zoom Eyepiece

NEW!

The finest zoom eyepiece available. High-resolution 7-element multi-coated optics, with 55° field at 8mm. Graduated scale in 1mm units indicates exact focal length in use. High-eyepoint yields comfortable observing even with eyeglasses. Internal zoom lenses move on the smoothest, most precisely-machined tracks yet developed for zoom optics. Performance is fully consistent with the finest fixed-focal length eyepieces. Threaded for filters; rubber eyecup; 1.25". **$219.95** (6.38)

ETX® Hard Carrying Cases

For secure storage or travel with your ETX. Thick-wall construction and die-cut foam lining. Accepts telescope, plus optional eyepieces, erecting prism, table tripod, hand controller, *etc.* Includes two steel latches with key.

#774 Case for ETX-90 models: **99.95** (8.58)

#775 for ETX-125EC: **149.95** (13.38)

#932 45° Erecting Prism for ETX®

For terrestrial observing with any ETX-90 or ETX-125 model. Yields correctly oriented image and convenient 45° observing angle. Threads to ETX rear cell. Accepts any 1.25" eyepieces. Coated roof prism optics. **$49.95** (3.86)

Advanced Field Tripod for ETX-125

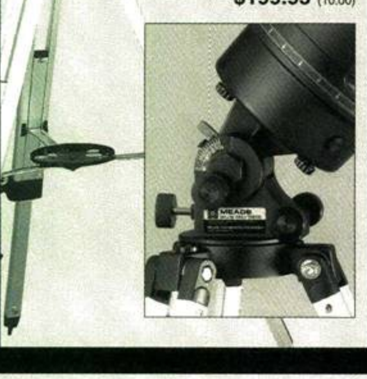
#887: Yields *rock-solid* stability for sensitive applications of the ETX-125, even at high magnifications. **Includes fixed-height tripod convenient for standing observations, equatorial wedge with alignment controls in azimuth and latitude angle, and #889 Tripod Adapter for ETX-125.** Permits either altazimuth or equatorial orientation of the telescope for astronomical or terrestrial observing. Tripod legs are 2"-diameter chromed steel. For field use the tripod collapses for easy transport. **$349.95** (14.00)

Tripod Adapter for ETX-125

Included with the #887 Tripod *(above)*, the #889 Adapter is available separately and permits attachment of ETX-125 directly to any Meade LX10, LX50, or LX200 Schmidt-Cassegrain Field Tripod for altazimuth observing or to any Meade Schmidt-Cassegrain Tripod-with-Equatorial Wedge or Superwedge for equatorial applications.

#889 Adapter: **$69.95** (7.70)

ETX® Deluxe Field Tripod



#883: Custom-designed by Meade specifically for ETX-90 and ETX-125 Astro Telescopes. Tripod height adjusts from 34" to 54", for seated or standing observations. Micrometric controls in azimuth and elevation permit precise polar alignment of the ETX fork mount. Tripod head tilts and locks to 90° for terrestrial applications. Telescope attaches to tripod in seconds with 2 thumbscrews. All-aluminum construction. **$199.95** (10.00)

ETX® Carry Bag

Soft-padded Cordura-type carry bag with shoulder strap; permits storage of any 90mm ETX model, plus table tripod legs, eyepieces, other accessories. **$36.95** (5.26)

Electric Focusers for ETX®

NEW!
ELECTRONIC CONTROLLER
MEADE

Meade-engineered for smooth, rapid focusing with any ETX model. Four-speed operation from coarse to microfine. Standard-equipment hand controller accepts one 9v. (user-supplied) battery and focuses all ETX telescopes. Or focus ETX/EC models through the telescope's hand controller.

#1244 Electric Focuser for all ETX-90 models: **$119.95** (6.85)

#1247 Electric Focuser for ETX-125 models: **$119.95** (6.85)

HOW TO ORDER

Prices shown are suggested U.S.A. mail-order retail prices and do not include any applicable sales taxes. Suggested shipping and handling charges to the 48 states by U.P.S. or U.S. Mail shown in ( ) next to each price. **The following national mail-order dealers carry all Meade accessories in-stock for immediate shipment:**

ASTRONOMICS, Norman, OK.
Orders: 800-422-7876; Info.: 405-364-0858.

FOCUS CAMERA, Brooklyn, NY.
Orders: 800-221-0828; Info.: 718-436-6262.

LUMICON, Livermore, CA.
Orders: 800-767-9576; Info.: 925-447-9570.

OCEANSIDE PHOTO & TELESCOPE, Oceanside, CA.
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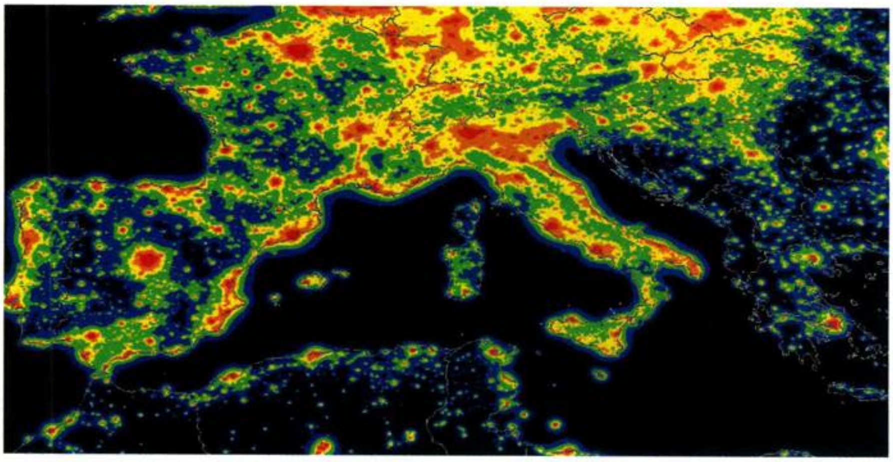

P. Cinzano, F. Falchi, C.D. Elvidge, K. Baugh

Brightness to boot: Various colors represent the brightness ratio between Europe's artificial and natural lighting. The difference increases as follows: <0.11 black; 0.11 – 0.33 blue; 0.33 – 1 green; 1 – 3 yellow; 3 – 9 orange; >9 red.

I have been an astrophotographer for 40 years. Two years ago I took up digital photography. I own two SCTs, several telephoto lenses, and top-of-the-line cameras. I've been to two total eclipses and two annular eclipses. Despite this, most of the time I use my 8x80 binoculars for observing.

My first recommendation for beginning astronomers is to buy a good pair of binoculars, 7x50 or larger. Then you can learn the sky well enough to justify the cost of a telescope. — *Larry W. Ostrander, Escondido, California*

Good advice from a seasoned observer. Astronomy*'s June 2001 issue will feature an exhaustive review of binoculars. —* Astronomy *editors*

Dark Sky Success Story

Cielobuio, an Italian association against light pollution and a branch of the International Dark Sky Association (IDA), played a fundamental role in passing one of the most advanced light pollution laws in the world.

Through its electronic mailing list, Cielobuio (Dark Sky) collected over 25,000 signatures in support of dark skies. The law took effect in March 2000 in the Lombardy Region of Northern Italy — a region that covers 24,000 square kilometers and has over nine million inhabitants.

The law protects the sky around all new public and private installations over the Lombardy Region. It not only prohibits the use of lighting fixtures that emit a flux above the horizon, but also requires full cut-off fixtures around its 25 local astronomical observatories. Replacement of non-compliant fixtures near existing observatories must occur within four years.

Cielobuio hopes to use its strong ties with the IDA and UAI (Unione Astrofili Italiani), to extend the bill to other Italian regions, and eventually into a national law. Right now, six out of 20 of Italy's regions protect their skies with special lighting regulations.

For more information on Cielobuio's fight against light pollution, go to the following website: www.inquinamentoluminoso.it. — *Fabio Falchi, Virgilio, Italy*

Day Trippers

On a mid-January afternoon I was watching the flight of a passenger jet when I noticed a bright sky object. At first I thought it was a weather balloon — then I noticed that it appeared to follow the ecliptic, moving at the same rate as the sun.

Finally, I set up my 6-inch Newtonian and realized that I had been watching Venus at a distinct "quarter" illumination! Is it ever possible to observe the gas giants during daylight hours as well? Will the moons of Jupiter be visible to a well-trained eye? How about the rings of Saturn? — *David Magart, Shreveport, Louisiana*

Good eyes, David. And good guesses, as well. While there's no way you'll see any jovian moons during the day, you might catch a glimpse of Jupiter itself. Wait until early October and look about 90° west of the sun anytime before noon. As far as seeing Saturn goes, don't bet on it: likewise for its rings. — Astronomy *editors*

Corrections

In "Margaret Geller: Star Mapper" (November 2000, page 104), *Astronomy* used a photo of Harvard professor Margaret Geller taken by Massachusetts photographer Steve Edson. We inadvertently dropped the photo credit. Our apologies to Mr. Edson.

Steve Edson

Astronomy also apologizes to Graeme Smith of Ayrshire, Scotland, who was listed as living in England on page 14 of the February 2001 issue. ◼

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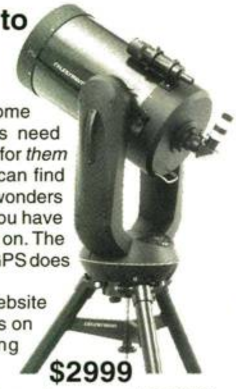

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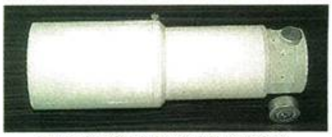
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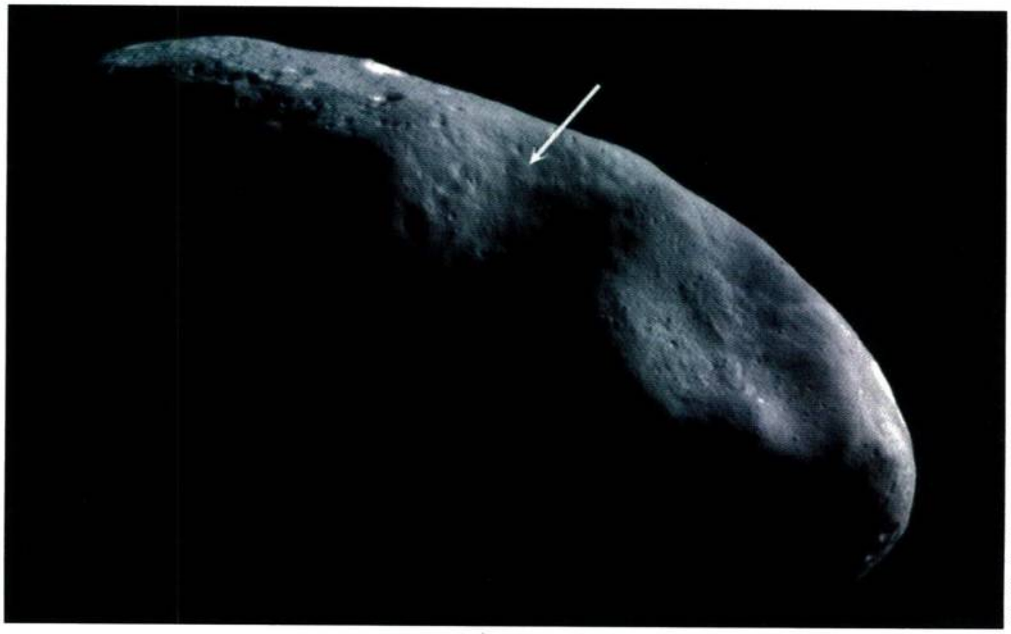
NEAR-EARTH ASTEROID RENDEZVOUS

NEAR-Shoemaker Scores a Touchdown



Johns Hopkins University and NASA

The landing site (arrow) lay just outside the saddle-shaped depression known as Himeros.

At precisely 3:02 P.M. EST on February 12, 2001, the American space probe NEAR-Shoemaker, designed to orbit the near-Earth asteroid 433 Eros, made an audacious attempt to land on its surface. To almost everyone's astonishment, the attempt succeeded.

"This was maybe the softest landing of all time," says Robert Farquhar, mission director and the man who had first suggested the attempt. Despite having no landing mechanism of any kind, NEAR-Shoemaker not only touched the surface of Eros, it survived the impact seemingly whole and in operation. Within 48 hours, NASA decided to extend the mission for ten days to allow the spacecraft's gamma-ray spectrometer to gather data about the chemical make-up of the landing site.

Ninety seconds into the spacecraft's final burn, two of its four solar panels touched the ground at the gentle speed of 3.5 miles per hour, and in response, the engines cut off and the main body settled on the surface. For about half a minute, the spacecraft's computer was confused. It quickly adjusted to its new circumstances, however, and reacquired contact with Earth, sending a beacon to tell the world that it had landed softly on the dirt-strewn surface.

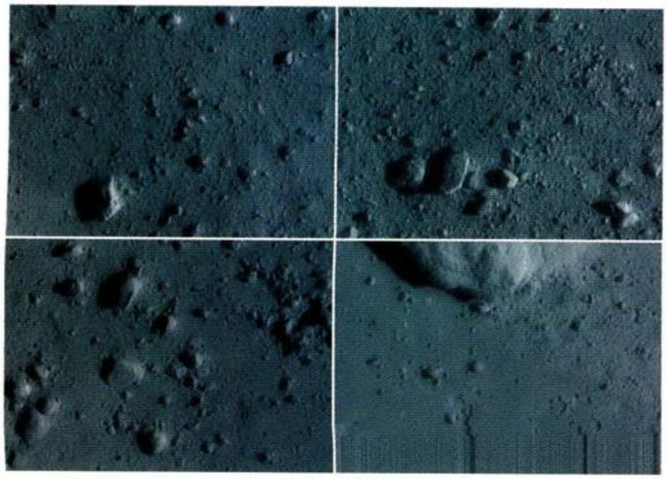
On its way down, NEAR-Shoemaker snapped 69 high-resolution images of the asteroid's surface, revealing details less than an inch across in the final ones. Planetary scientists were eager to study these better views in the hope that they might help explain two strange phenomena discovered only recently.

First, scientists have found that many of Eros's innumerable boulders have debris-strewn aprons, as if some process is causing the rocks to crumble over time. Second, the closest views of some crater floors show what appear to be extremely smooth ponds of material, as if the finest particles of dust and dirt somehow have slid down the sides of the craters and pooled there.

To everyone's delight and amazement, NEAR-Shoemaker's last image, partly cut off when the spacecraft landed, captured the edge of one of these "sand ponds." While small pebbles can be seen peeking through the surface, the ponded area still appears remarkably uniform.

Even more intriguing, two tiny pits lie in the sand pond, as though underground cracks have allowed some surface material to drain down. "These images leave us with mysteries that will have us scratching our heads for years to come," says Joseph Veverka of Cornell University, lead scientist of NEAR's imaging team. — ROBERT ZIMMERMAN

NEAR-Shoemaker took these images from 3,770 feet, 2,300 feet, 820 feet, and 390 feet, respectively (left to right and top to bottom). The last image shows details less than an inch across; the bottom of it was lost when the spacecraft touched down.



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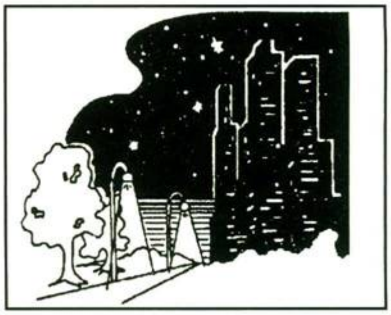

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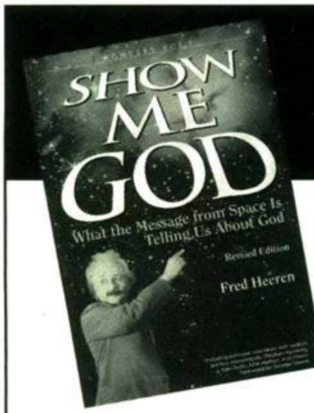

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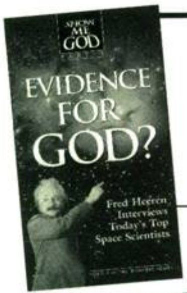

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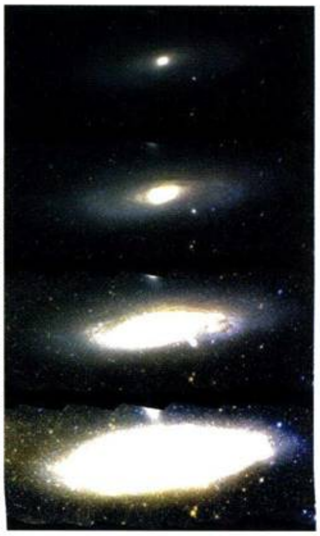
The Milky Way's Twisted Sister

As the largest galaxy in the Milky Way's vicinity, the Andromeda Galaxy (M31) has been scrutinized like no other. Yet even this old friend holds a few surprises.

According to the latest research from University of California (UC) astronomers, M31 may harbor signs of a twisted past. The team, led by Puragra Guhathakurta and Philip Choi at UC, Santa Cruz, recently released convincing evidence for a huge warp in the disk of M31. What's more, it just might be the most extreme case of galaxy warp ever seen in a spiral galaxy.

Many spiral galaxies show warps in their disks, much like a vinyl record album that's been exposed to high heat. Even the Milky Way Galaxy displays signs of a slight warp. Most astronomers think that interactions with other galaxies create these warps. Others believe that warps arise when magnetic fields couple with the interstellar medium or perhaps in interactions with dark matter. Whatever the cause, astronomers hope that understanding galaxy warps will help them to grasp the dynamics and evolution of spiral galaxies.

The disk of the Andromeda Galaxy seems to be warped. This warp appears most prominent on the disk's northeast side (left), and shows up best at very high contrast levels (bottom).



Puragra Guhathakurta, Philip Choi, and Somak Raychaudhury

Spiral galaxies, such as M31 and the Milky Way, typically consist of a disk and a spheroid component. The disk — which contains gas, dust, and stars — is usually flat and orderly, while the spheroid features stars in random orbits that envelop the galaxy core like a swarm of bees.

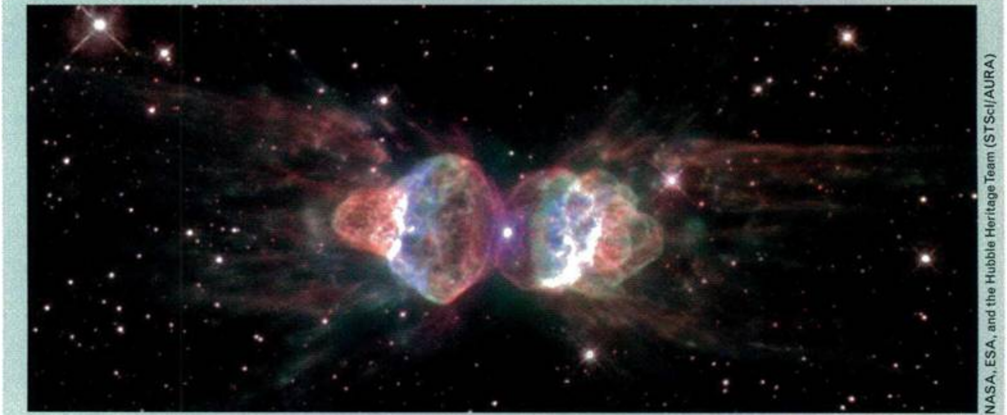
When a galaxy's disk becomes warped, the effect shows up most clearly near the disk's outer edge. But because the outer region usually appears much fainter than the interior, it's often hard to detect such warps. "The outer parts are more susceptible to warping," says Guhathakurta, "because they are less strongly bound by the gravitational forces that keep the disk in a plane, and they are also more susceptible to the influence of neighboring galaxies."

Previous photographic surveys of M31 hinted that the stellar disk might be warped. Guhathakurta and his team produced the first convincing evidence using images taken with a large-format CCD detector attached to the 0.9-meter Burrell-Schmidt telescope at Kitt Peak National Observatory in Arizona. Their observations clearly show a characteristic S shape caused by warping in the outer reaches of the disk.

Team member David Reitzel, who now works at UC, Irvine, gathered additional evidence that shows just how extreme M31's warp may be. While a graduate student at UC, Santa Cruz, he used the 10-meter Keck II telescope on Mauna Kea to study red-giant stars in the spheroid of M31.

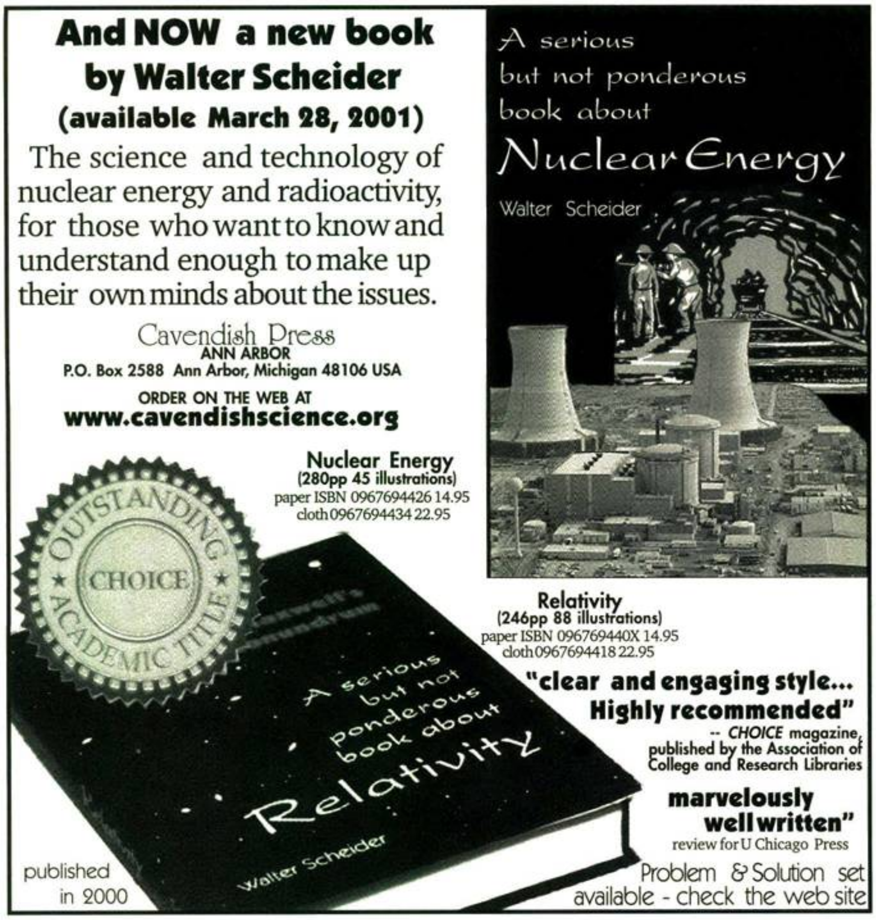
To their surprise, he and Guhathakurta found that several of these stars possessed the properties of disk stars. "We were trying to get as far away from the disk as possible," explains Guhathakurta, "and had calculated the probability of finding a disk star where we were looking to be much less than 1 percent." If these stars indeed belong to Andromeda's disk, the two observations combine to make a strong case for a major warp in the disk of M31. — William Schomaker

HUBBLE SPACE TELESCOPE



NASA, ESA, and the Hubble Heritage Team (STScI/AURA)

IF THIS IS THE SUN'S FATE in 5 billion years, we may all want to stick around to see the show. To ground-based telescopes, the planetary nebula dubbed the Ant Nebula (Menzel 3) in the constellation Norma resembles the head and thorax of a garden-variety ant. But when seen with the Hubble Space Telescope, the body resolves into a pair of fiery lobes projecting from a dying, sunlike star. Although most low- and medium-mass stars end their lives by ejecting a planetary nebula, Hubble — which has observed scores of these objects — has yet to find one like the Ant. What most intrigues astronomers is its symmetric but non-spherical shape. They suspect that either a close companion or a strong magnetic field creates the unique shape.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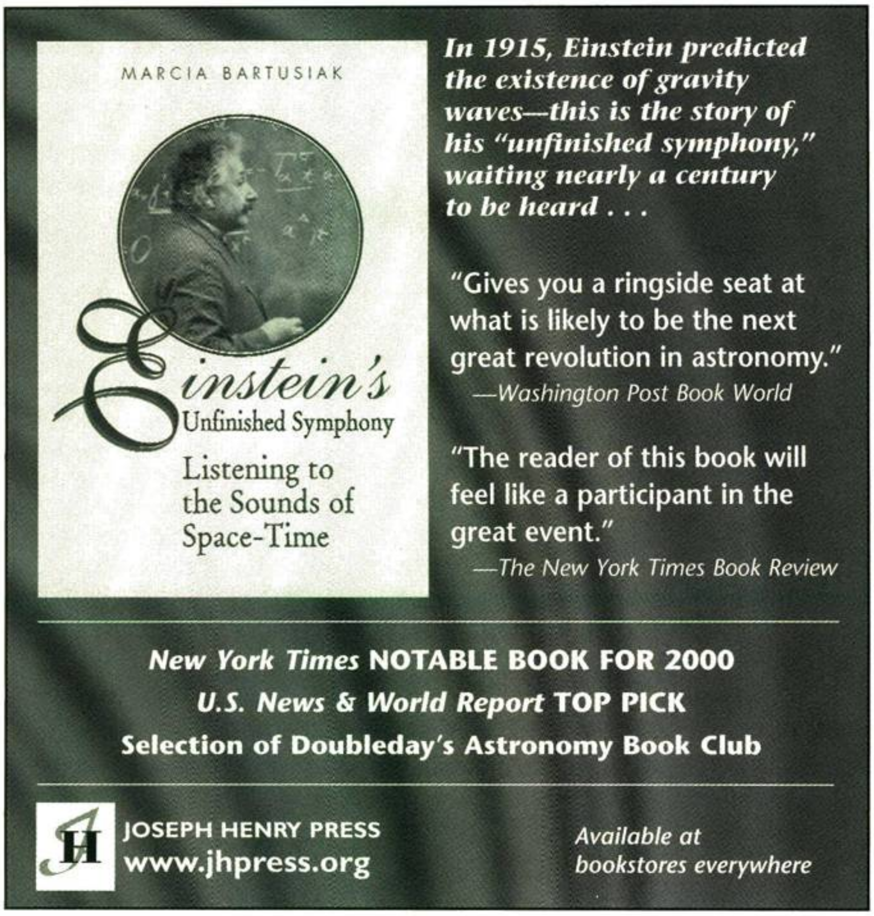
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BLACK HOLES

Seeing an Invisible Horizon

▶ How can astronomers see something that emits no light? When it comes to black holes, two recent examples prove ingenuity and perseverance are valuable allies: Astronomers now have compelling evidence for the existence of event horizons — the boundary that cuts a black hole off from the rest of the universe.

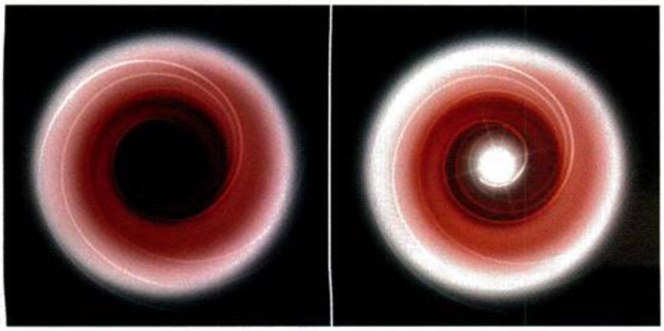
Michael Garcia of the Harvard-Smithsonian Center for Astrophysics and his colleagues used the Chandra X-ray Observatory to examine a dozen x-ray novae, binary systems that contain one sunlike star in orbit around a collapsed object, either a neutron star or black hole. Such systems occasionally flare into brilliance (hence the name "novae") and then settle into decades of dormancy. The researchers studied only inactive x-ray novae.

The team found that systems containing black hole candidates emitted just one percent as much energy as those with neutron stars. "It's a bit odd to say we've discovered something by seeing almost nothing," says Garcia, "but in essence this is what we have done."

As matter swirls in the accretion disk surrounding the neutron star or black hole, some of it inevitably falls toward the collapsed object. Because a neutron star has a solid surface, when the material strikes it, copious x rays get released. But with a black hole, only a tiny amount of energy can escape before the material approaches the event horizon and vanishes forever.

While Garcia's team used the state-of-the-art Chandra Observatory, Joseph Dolan of NASA's Goddard Space Flight Center mined data from an obsolete piece of equipment. The High Speed Photometer, one of the Hubble Space Telescope's original instruments, was replaced during the first servicing mission back in December 1993.

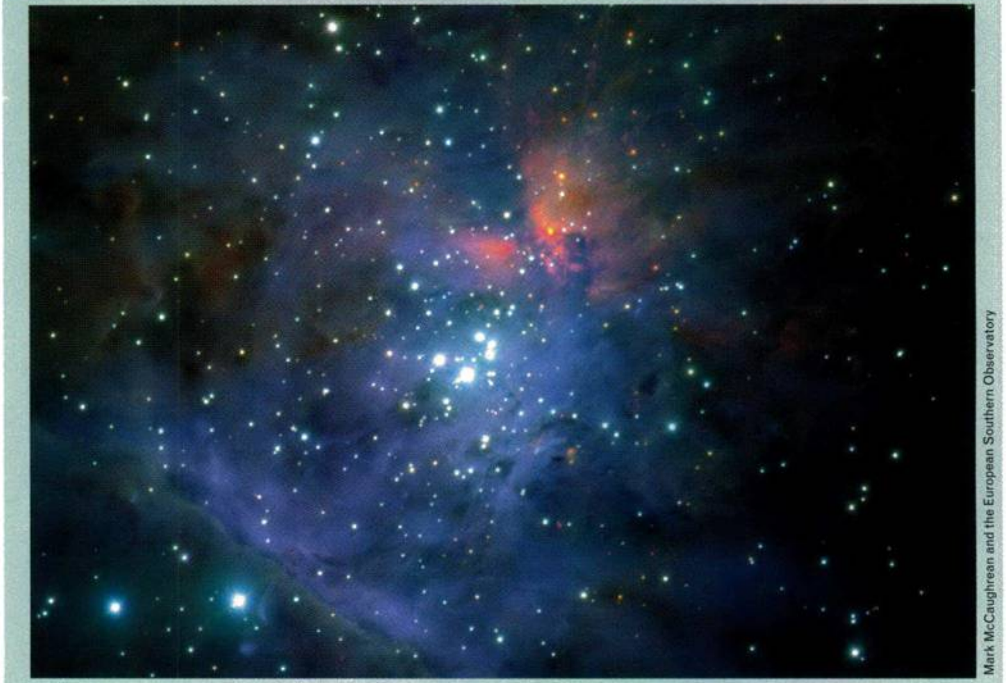
Dolan looked at observations of the black hole candidate Cygnus X-1, searching for the death cry of matter falling into the black hole. The photometer measured the object's ultraviolet light 100,000 times each second for three hours. When Dolan analyzed the data, he found two "dying pulse trains" — the rapidly decaying, precisely sequential flashes of light expected



CXC/M. Weiss

A new study shows that when gas falls into a black hole (left), it disappears over the event horizon with little trace. But when it hits the surface of a neutron star (right), it glows brightly in x rays.

VERY LARGE TELESCOPE



Mark McCaughrean and the European Southern Observatory

A JEWEL IN THE SWORD of Orion, the Orion Nebula (M42) remains a hotbed of star formation just 1,500 light-years from Earth. This near-infrared image, taken with the ISAAC camera on the European Southern Observatory's 8.2-meter Very Large Telescope, hones in on the Trapezium Cluster that lies at the heart of the nebula. At visible wavelengths, this densely populated cluster is partially drowned out by the nebula's light and obscured by the nebula's dust. At these longer wavelengths, however, the cluster shines through much more clearly. About 1,000 stars born within the past million years crowd into this volume, which spans a region of space less than the distance between the sun and its nearest stellar neighbor.

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RICHARD WOLFSON (Ph.D., Dartmouth College) is Professor of Physics at Middlebury College in Vermont, where he has also held the George Adams Ellis Chair in the Liberal Arts. Decades of teaching at Middlebury, with its strong emphasis on the humanities, has made him an expert at demonstrating the logic and significance of physics to students from many fields. His wide-ranging research interests include plasma physics, medical physics, solar-energy engineering, global climate change, and theoretical astrophysics. His writings have appeared in *Scientific American*, and he is the author of the textbook *Physics for Scientists and Engineers*, now in its 3d edition.

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from a hot blob of gas spiraling into a black hole. One event showed six pulses, the other seven; both lasted just 0.2 second before disappearing from view.

Dolan cautions that with only two events, the signature could be a statistical fluke that mimics the behavior expected from a black hole. But he adds: "Things in science are like cockroaches: Once you see one or two, pretty soon you see hundreds." — Richard Talcott

GALILEAN MOONS

An Ocean for Ganymede, Too

▶ When it comes to harboring liquid-water oceans, Jupiter's three big icy moons seem like peas in a pod. Earlier observations from NASA's Galileo spacecraft found strong evidence for oceans beneath the icy surfaces of Europa and Callisto. And now three Galileo instruments have yielded evidence for an ocean deep under Ganymede's surface.

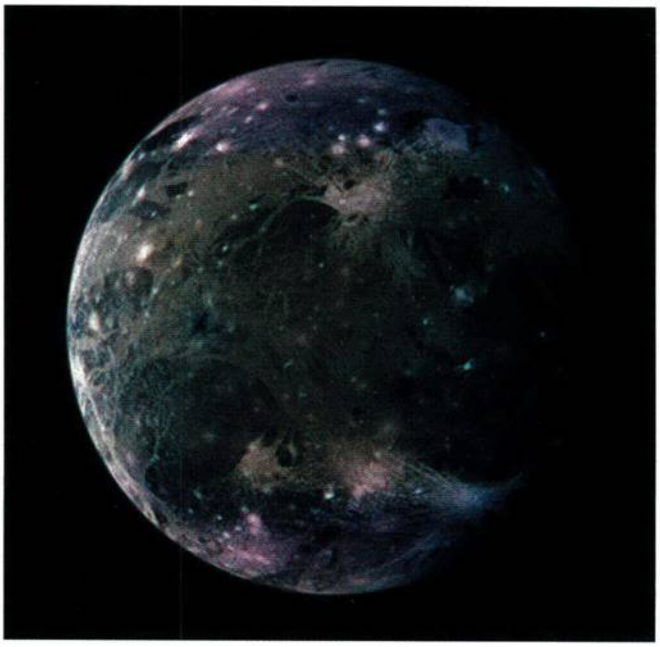
Galileo's magnetometer registered a fluctuating magnetic field around Ganymede that varies in sync with Jupiter's 10-hour rotation period. These fluctuations probably arise when currents generated by the planet's powerful magnetic field surge through an electrically conducting layer below Ganymede's surface.

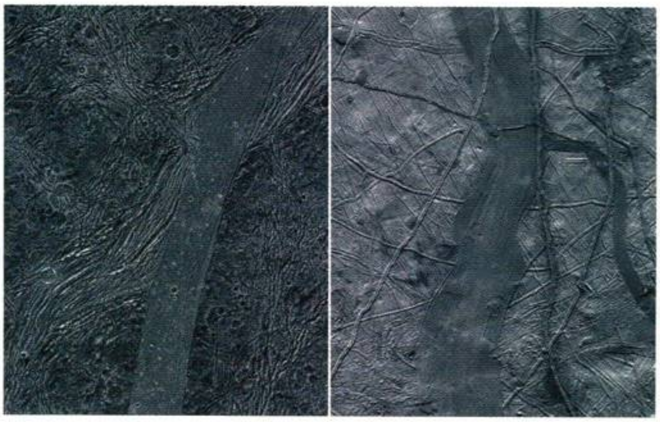
The magnetometer team, led by Margaret Kivelson of UCLA, previously found similar fluctuations around Callisto and Europa. In all three cases, the team concluded that a global layer of subsurface saltwater (a very good conductor) explained the fluctuations better than any other type of material.

Of the three moons, Ganymede was the toughest nut to crack. Unlike Europa and Callisto, Ganymede generates its own magnetic field, which partially masks the fluctuating field. To sort out the effects, Kivelson's group developed a model that assumes a saltwater ocean lies about 100 miles below the surface. "Using this model, we predicted the exact signature seen by Galileo's magnetometer during its third close Ganymede flyby," says team member Krishan Khurana of UCLA, referring to the flyby of May 20, 2000.

Galileo's imager provided a second line of evidence. In detailed images taken during the May 20 flyby, geologists found striking similarities to features on Europa thought to be caused by the upwelling of water or slushy ice to fill linear fractures in the crust.

Third, the spacecraft's Near-Infrared Mapping Spectrometer (NIMS) found hydrated salts on the surface of Ganymede. Saltwater from deep down could have lifted these minerals to the surface, where they were left behind when the water evaporated into the vacuum of space. NIMS has found similar deposits on Europa.





Bright grooved terrain and older, darker areas dominate the trailing hemisphere of Ganymede (top). Similarities between that moon's grooved terrain (above, left) and Europa's (above, right) hint at a subsurface ocean. NASA/JPL

With a diameter of 3,270 miles, Ganymede is the largest satellite in the solar system and larger than Mercury or Pluto. It consists of water ice and rock. Radioactive elements deep in Ganymede's interior generate heat, which should be capable of melting a layer of water ice at a depth of about 100 miles. Kivelson's model suggests that the water layer is at least three miles thick, meaning Ganymede's ocean contains nearly as much or more water than all the oceans on Earth combined.

Liquid water is a key ingredient for life on Earth, so the discoveries of liquid-water oceans under Jupiter's moons certainly enhance the prospects of finding extraterrestrial life in the solar system. The problem with Ganymede, however, is that the water ocean is deep down, where it would be hard to reach. "If we find that life exists on Europa, I would be surprised if it doesn't exist on Ganymede," says Khurana. "There are similar conditions on both worlds, but Europa's ocean is much closer to the surface. One could think about getting to it with landers."

Scientists will be on the lookout for signs of subsurface oceans on the moons of Saturn when Cassini arrives in July 2004. "There is a very good chance that we'll see evidence of an ocean inside one or more of Saturn's icy moons," says Khurana. — Robert Naeye, Astronomical Society of the Pacific

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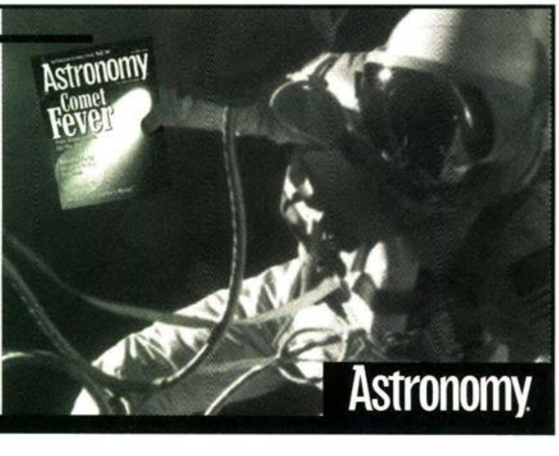

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GALAXY CLUSTERS

Spying a Super-Supercluster

▶ Like a lighthouse beacon marking the foggy coast for a ship of weary mariners, a large group of quasars recently enabled astronomers to detect the largest known structure in the observable universe. The massive galaxy supercluster, located in the constellation Leo, spans 600 million light-years from end to end and lies some 6.5 billion light-years from Earth.

The universe was only one-third its present age when light left the supercluster — Earth hadn't even formed yet — and astronomers are puzzled by how such a large structure could have formed so quickly. Conventional theory suggests that an unusually large concentration of primordial material must have been present to allow the massive cluster to coalesce under the weight of its gravity. Researchers are currently attempting to measure the mass of the supercluster to test these theories.

"A successful theory has to explain the extremes," says Gerard Williger of NASA's Goddard Space Flight Center and the National Optical Astronomy Observatories. "Bizarre things like this huge supercluster present a unique opportunity to measure how well quasars and galaxies reveal the mass in such a big region of space." Williger presented the results at the January meeting of the American Astronomical Society in San Diego, California.

Prior to this research, astronomers had known that the same region harbored an unusually large concentration of distant quasars — ultraluminous galaxy cores powered by accretion onto central supermassive black holes. Six times the expected number of quasars had been cataloged in the region.

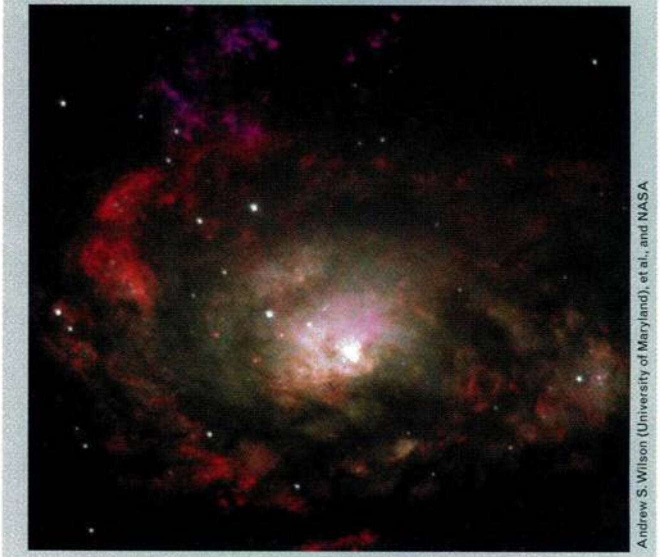
Williger and an international team of collaborators used the 4-meter telescope located at Cerro Tololo Inter-American Observatory in Chile to detect the galaxies associated with the quasar group. Magnesium gas in the diffuse halos surrounding the otherwise invisible galaxies absorbed light from distant quasars, leaving a spectral fingerprint betraying their presence.

"At the moment, computer simulations of the formation of large structures in the universe are just starting to deal with sizes as large as this group," says Williger. "These groups are fantastic laboratories for studying the formation and evolution of quasars and galaxies." — W. S.

NSF, NOAO, Chris Haines, and Gerard Williger

A small part of the largest supercluster yet discovered contains hundreds of galaxies (a few of the brightest are foreground objects).

HUBBLE SPACE TELESCOPE



Andrew S. Wilson (University of Maryland), et al., and NASA

RADIATION POURS FROM THE HEART of this active galaxy located in Circinus. The Circinus Galaxy is classified as a Seyfert because it possesses a compact center harboring what's most likely a supermassive black hole, which powers the galaxy as it accretes gas and dust from its surroundings. Much of the gas in the galaxy and a significant fraction of the star formation concentrates in two rings: a large one with a diameter of 1,300 light-years and a smaller one just 260 light-years across. This Hubble image reveals the inner ring, located on the inside of the green disk, for the first time. (The outer ring extends off the image.) Although the galaxy lies nearby — at a distance of 13 million light-years — it went unnoticed until 25 years ago because it lies near the plane of our own galaxy and intervening dust partially hides it.

DARK MATTER

MACHO Team Has Reason to Boast

▶ Astronomers have long believed that the Milky Way's dark matter resides in a large, spherical halo that extends about 10 times beyond the edge of the galaxy's disk. Some contend that small, dark objects like planets, brown dwarfs, low-mass stars, neutron stars, and lightweight black holes

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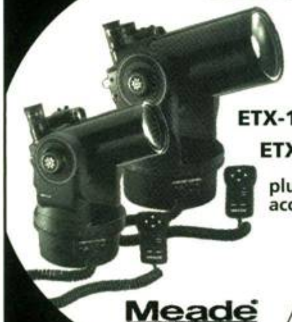

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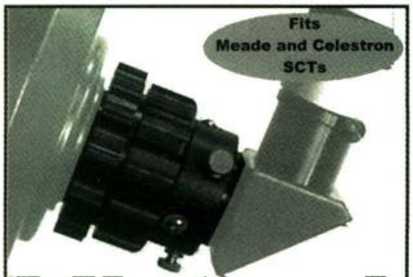

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Patent Pending

— called MACHOs (for MAssive Compact Halo Objects) — compose a large fraction of the halo's dark matter. The latest news from the MACHO collaboration strongly suggests that they've had it right all along.

Because dark matter, by definition, doesn't emit detectable amounts of light, researchers must discern its presence through alternative means, such as its gravitational interaction with stars and galaxies. One such method is called microlensing. For eight years, the MACHO collaboration has trained its 1.27-meter telescope at Australia's Mount Stromlo Observatory on stars in the nearby Large Magellanic Cloud (LMC), searching for the microlensing signatures of MACHOs residing in the Milky Way's halo.

When a MACHO passes in front of a background star in the LMC, its gravity acts like a lens and momentarily causes the more distant star (called the source star) to brighten. To the surprise of many doubtful colleagues, the MACHO collaboration has recorded numerous microlensing signatures. Based on the observations, the team concludes that MACHOs make up about 20 percent of the total mass in the Milky Way's dark halo.

The Large Magellanic Cloud has been one target for astronomers on the lookout for dark matter.

Mike Mayerchak

Still, not all astronomers agree that the objects causing these microlensing events reside in the Milky Way. Competing explanations favor the possibility that source stars in the LMC are being lensed by closer LMC stars. Thankfully, a simple test with the Hubble Space Telescope can settle the argument.

If LMC stars are being lensed by other LMC stars, Hubble observations should show that all the source stars lie on the far side of the LMC. Conversely, if MACHOs are to blame, then the source stars should be distributed randomly throughout the LMC. Two members of the MACHO collaboration, Cailin Nelson and Kem Cook of Lawrence Livermore National Laboratory, announced the results of the Hubble test in January. To their delight, it appears that the source stars are distributed randomly.

"Our analysis has determined that it's very unlikely that microlensing is due to some strange population of source stars," says Nelson. "The most likely explanation remains that microlensing events are caused by dark matter MACHOs in the halo of the Milky Way."

Although the MACHO collaboration's latest observations bolster the premise that at least some dark matter exists in the form of normal matter, most theories still point to some yet-unseen exotic particle making up the majority of the universe's dark matter. The affectionately named Weakly Interacting Massive Particle (WIMP) is just one such possibility. — W. S.

New Mission Could Look for Planets

It's going to be a tough decision, but only one of three remaining Discovery Mission proposals will make it to launch in 2005 or 2006. In the first round of the decision process, 26 proposals were whittled to the three NASA judged to have the best science value. Each team got $450,000 to conduct a detailed study and the winner, to be announced in late 2001, will walk away with a prize of nearly $300 million. William Borucki of NASA's Ames Research Center leads the Kepler project, a specially designed telescope that will search the solar neighborhood for Earth-sized planets. Project scientists expect Kepler to find more than 500 Earth-sized planets and 1,000 Jupiter-sized planets during a 4-year mission. The other missions are focused closer to home. The Interior Structure and Internal Dynamical Evolution of Jupiter (INSIDE Jupiter) mission, led by Edward Smith of the Jet Propulsion Laboratory, will orbit the giant planet and make high-resolution maps of its magnetic and gravity fields. The third project, called Dawn and led by Christopher Russell of UCLA, will orbit both Ceres and Vesta. The two asteroids formed and evolved in different parts of the solar system, and scientists hope Dawn will help them better understand the early solar system.

NASA/STScI

Asteroid Vesta is one target for a possible Discovery Mission.

Radioactive Star Turns up in Milky Way

Although it doesn't shine by nuclear power, an otherwise unassuming star has become the first place outside the solar system where astronomers have detected uranium. The star, designated CS 31082–001, belongs to a newly recognized group of stars with extremely low levels of heavy elements, a thousandth of the sun's abundance or less. The low levels mean that in a spectrum of the star, rare elements like uranium-238 aren't overwhelmed by more common elements. A team led by Roger Cayrel of the Paris Observatory detected the uranium in a spectrum taken with the European Southern Observatory's 8.2-meter Very Large Telescope. Because uranium-238 has a known half-life of 4.47 billion years, the researchers estimate that the star was born roughly 12.5 billion years ago.

European Southern Observatory

Astronomers discovered uranium in the star at the center of this image.

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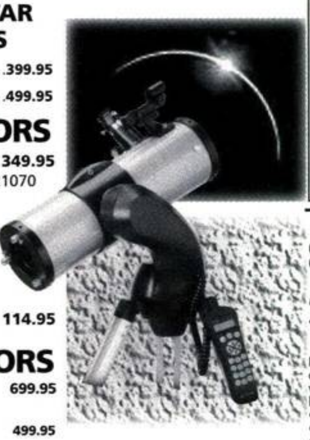

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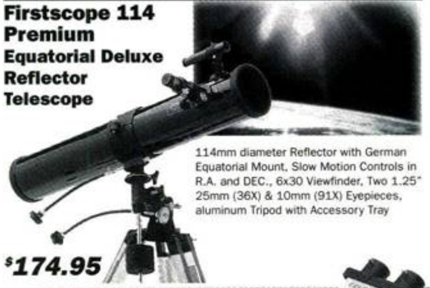

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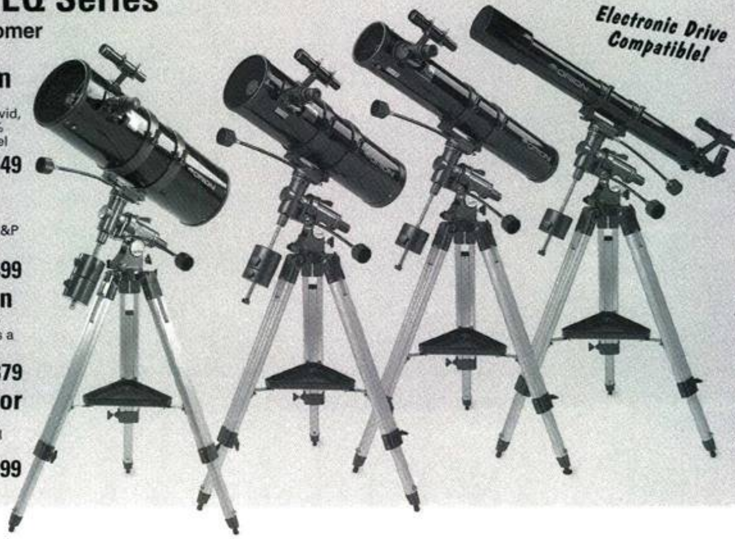

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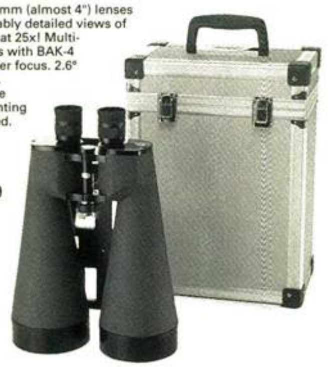

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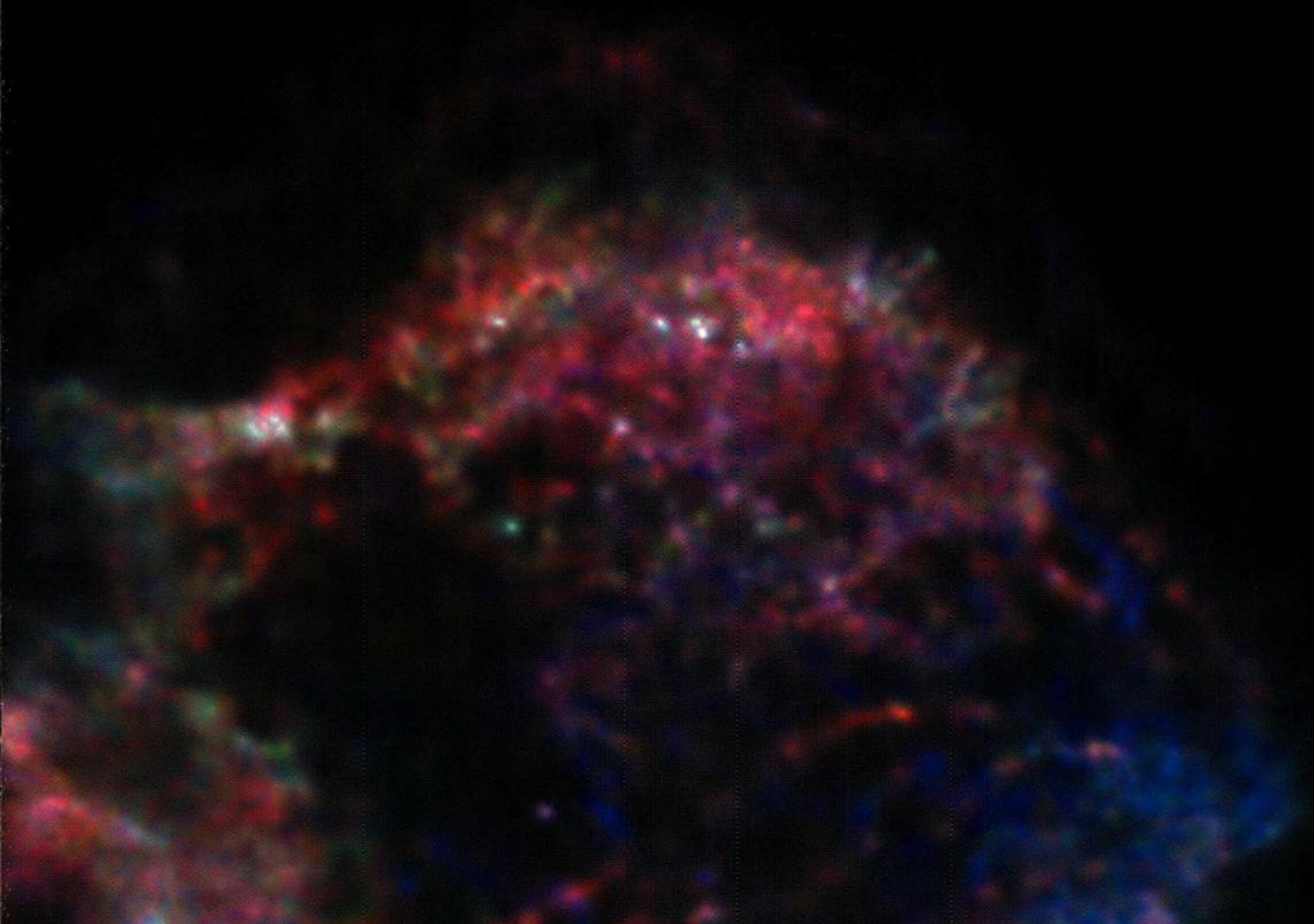
SEEING WITH X-RAY EYES

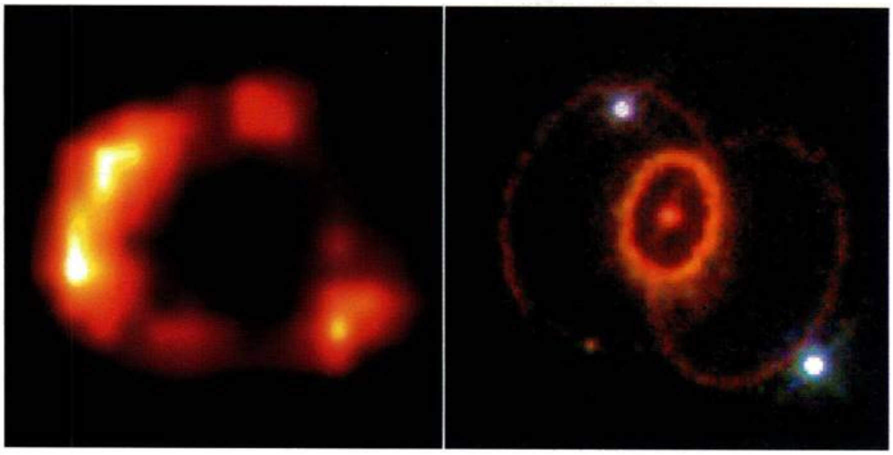
The Chandra X-ray Observatory is giving astronomers their sharpest view ever of the high-temperature universe.

by Robert Zimmerman

Since the Chandra X-ray Observatory went into full operation in December 1999, astronomers have been scrambling madly to get the telescope aimed at as many major astronomical objects as possible. From high-speed jets to supernova remnants to galaxies, Chandra's superb ability to resolve a haze of x rays into a sharp image has kept scientists breathless with anticipation. And as Richard Mushotzky of the Goddard Space Flight Center in Maryland gleefully notes, "Chandra's results have been surprising and confusing — exactly what we expected."

Supernova remnant Cassiopeia A glows red, green, and blue, revealing low-, medium-, and high-energy x rays, respectively. NASA/CXC/SAO/Rutgers/J. Hughes





As the shock wave from Supernova 1987A rams into a preexisting ring of gas, the gas gets heated to 10 million degrees and glows in x rays (left). A wide-field optical image (right) shows the entire ring. Left: NASA/CXC/SAO/PSU/ D. Burrows, et al.; right: Christopher Burrows, ESA/STScI, and NASA

BABIES AND CORPSES

One of the most intriguing discoveries made so far by Chandra involves the very youngest stars. Chandra's images of nearby star-forming regions — in particular the molecular clouds in the constellations Orion and Ophiuchus — have shown that even stars in the earliest stages of development radiate x rays. The x-ray brightness of these extremely young stars fluctuates on a daily basis, some with bursts resembling stellar flares and occurring regardless of the object's rotation, age, mass, or energy output. Even the youngest stars, thought to be less than 1,000 years old, have been found to emit powerful x rays.

These x rays imply high temperatures, from 10 to 100 million kelvins, far hotter than anything seen from the sun. They also imply that these baby stars very quickly become violent places as they struggle to settle down into relatively calm stars, like the sun we see shining so constantly in our blue sky. How stars get over this hurdle, however, remains a mystery.

Chandra has also examined several supernova remnants, the debris left behind after a massive star explodes. The remains of Supernova 1987A in the Large Magellanic Cloud naturally became one of its first targets, especially because the shock wave from the supernova explosion is currently crashing into and lighting up a gaseous ring ejected thousands of years ago by the progenitor star. Chandra's x-ray image, taken by a team led by David Burrows of Penn State University, reveals a close match with earlier optical and radio images. However, the x-ray emissions make the ring appear round while both the optical and radio observations give it an oval shape. The difference indicates that the optical emissions come from a physical ring tilted to the sky's plane while the x-ray emissions come from a spherical shell of material surrounding the central star on all sides.

Even more spectacular is the Chandra image of the supernova remnant surrounding the Vela pulsar. Now dubbed the Crossbow Nebula, this remnant, only 800 light-years away, shows arcs as well as jets flying away from the central pulsar. Its asymmetrical shape suggests that the initial supernova explosion was likewise asymmetrical and its two arcs imply the presence of two toruses, one each above and below the central pulsar. Interestingly, when David Helfand of Columbia University used Chandra to observe the pulsar 32 days apart in early 2000, he discovered that the outer arc had brightened by about five percent. Although he has no direct evidence yet to prove it, Helfand suspects that this brightening might be linked to a sudden but tiny speed-up of the pulsar's rotation (a "glitch," as astronomers call it) that occurred three days before his first observation.

Chandra has also found that supernovae may well be the source of the mysterious high-energy cosmic rays. Instead of using spectacular images, Patrick Slane of the Harvard-Smithsonian Center for Astrophysics and his collaborators took x-ray spectra of a number of specific, small regions in several supernova remnants, including Cassiopeia A. They found that some of the thermal, or heat, energy of these supernova blasts apparently has been converted into very high energy cosmic rays. Not only does this change many of the theories that estimate the age and density of some older supernova remnants, this cosmic energy very well might be one source for the cosmic rays that regularly strike Earth.

JETS EVERYWHERE

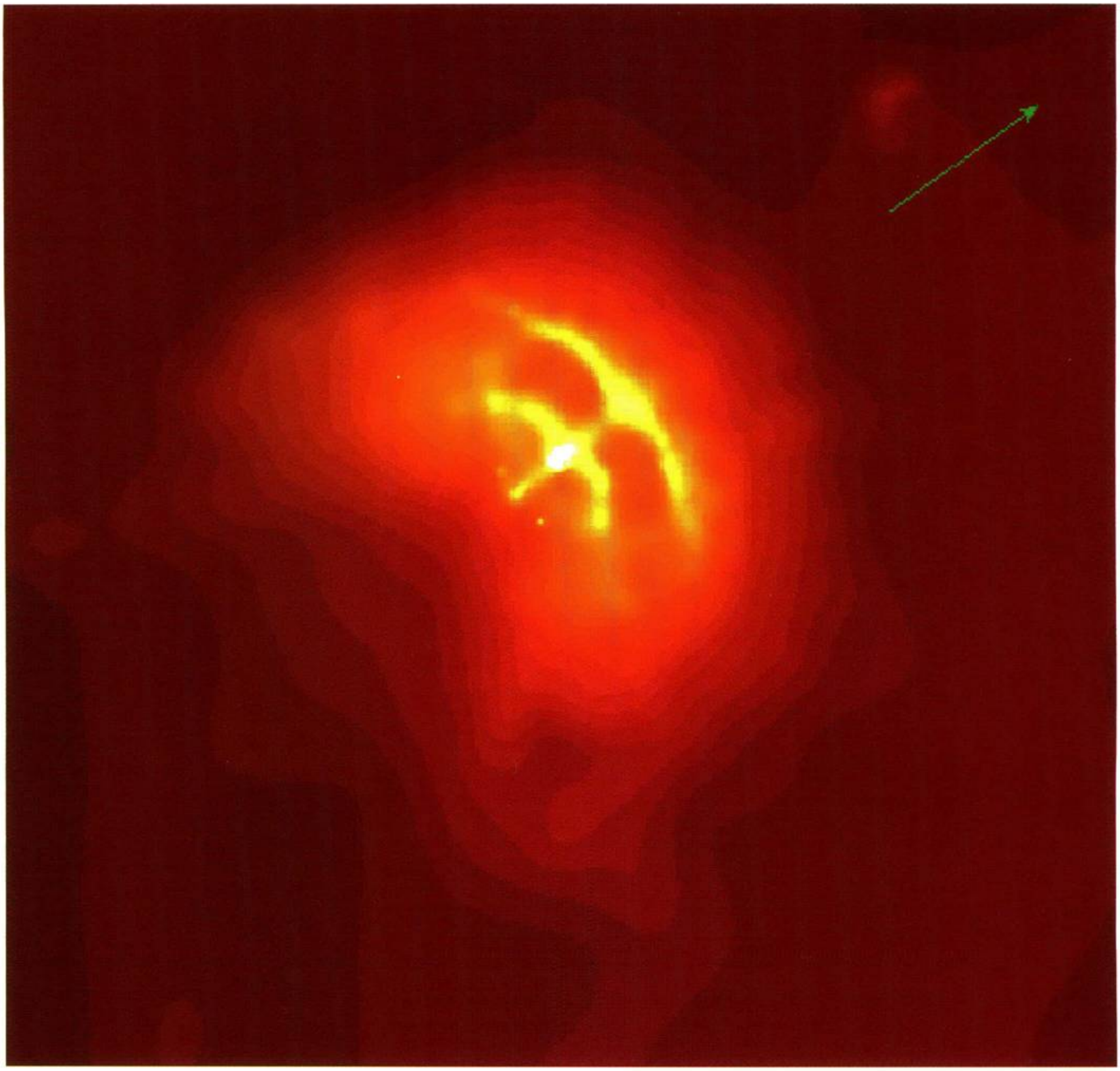
Astronomers also aimed Chandra at many of the astronomical jets that gush from quasars, galaxies, black holes, and even some stars. The nearest jet to our solar system — only 650 light-years away — shoots from R Aquarii, a Mira-type variable star thought to have a companion that's either a white dwarf or a hot subdwarf. Although the Chandra x-ray image closely matches previous radio and ultraviolet observations of the jet, it also shows the first evidence for a more extended counterjet on the system's far side. "This is probably a new feature," says Mike Hollis of the Goddard Space Flight Center, "which hasn't had time to decay into less energetic radiation."

Outside the Milky Way, one of the most famous jets spews from 3C 273, one of the first quasars discovered. The jet, closely studied since the 1960s, has been mapped in both the optical and radio wavelengths. In the optical, the jet looks like a series of braided knots, all the same brightness, which seem to weave back and forth so that the jet appears to be flying outward in the shape of a corkscrew. In the radio, the jet simply grows progressively brighter at greater distances from the quasar.

A team of scientists led by Herman Marshall of MIT aimed Chandra at 3C 273 and discovered that its jet appears far different in x rays: It's brightest close to the quasar and becomes steadily dimmer at greater distances. Most of the x rays appear to come from the regions of the jet that radiate the least in radio.

Observations of other jets, however, do not show the same kind of dichotomy. According to Dan Harris of the Harvard-Smithsonian Center for Astrophysics, of the 13 x-ray jets that Chandra has looked at, the radio and x-ray jets correspond reasonably well in about 80 percent of the cases.

Untangling this data remains difficult. Although it appears that the angle at which each individual jet is aimed at us contributes a great deal to



how the jet looks, Harris notes that "the research is not mature enough yet to come to any firm conclusions."

Chandra observations of other jets prove equally intriguing. Andrew Wilson of the University of Maryland led a team that used Chandra to examine Cygnus A, the brightest radio galaxy in the sky. Two gigantic jets stream from the galaxy's nucleus, each more than 300,000 light-years long or about 10 times the visible radius of the Milky Way Galaxy. The Chandra photographs reveal an enormous football-shaped cavity plowed out as the jets push their way through the gas that permeates the surrounding cluster's intergalactic space.

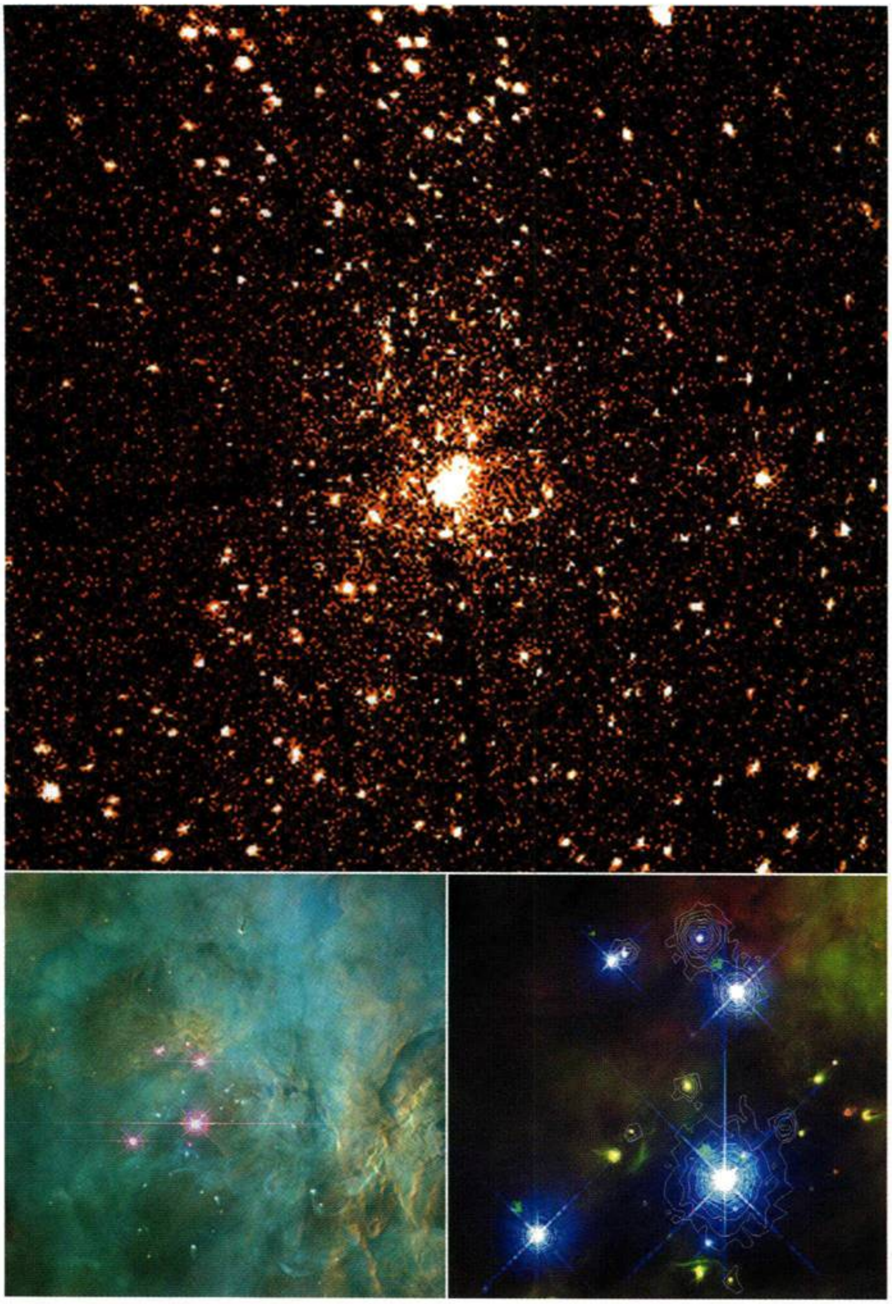
These results provide more evidence that some galactic jets are truly enormous objects, possibly the largest single coherent objects in the universe. In one case scientists estimated a jet's length at about a million light-years, three times longer than predicted.

NO CENTRAL OBJECTS

Before Chandra, the x-ray emissions from the centers of many galaxies were seen as blurry, diffuse glows. The observations available couldn't resolve whether these glows were caused by a single object at the center or many small point sources. But Chandra can resolve this blur, and scientists have rushed to take wide-angle images of these star cities. The findings have proved fascinating, especially in light of recent studies suggesting that the larger a galaxy's spherical bulge, the bigger the supermassive black hole that lies in the galaxy's center.

With spiral galaxies, Chandra has tended to confirm this relation. Jonathan McDowell of the Harvard-Smithsonian Center for Astrophysics used Chandra to look at the nearby face-on spiral M33, a galaxy with a very small bulge. He found about 100 x-ray

A high-speed jet spews from the Vela pulsar, which also created the asymmetric Crossbow Nebula. The jet points in the same direction as the pulsar moves (arrow). NASA/PSU/G. Pavlov, et al.



A thousand infant stars in the Orion Nebula glow brightly in x rays (top). The Trapezium cluster appears at center of this image and in more detail below (wide-field optical image at left; close-up optical image with x-ray contours at right). Top: NASA/PSU; below: John Bally, CASA Colorado

sources evenly scattered across the face of the galaxy with no concentration toward the center. "There is a very luminous and steady x-ray binary in the center," he says, "but it isn't a supermassive black hole."

Similarly, Chandra reveals no single large central object in M82, the closest starburst galaxy to the Milky Way and another galaxy with no appreciable bulge. Instead, the x-ray image shows a scattering of nine bright point sources near the galaxy's center, with the brightest and most variable object located 550 light-years from the center. Too small to be considered a supermassive black hole, this object is likely a medium-sized black hole with a mass somewhere between a thousand and a million times that of the sun.

With elliptical galaxies, however, Chandra's first look has thrown a wrench into this theory. Intuition naturally suggests that the biggest elliptical galaxies — which are essentially nothing more than big bulges — should harbor the biggest supermassive black holes. Moreover, astronomers think these ellipticals are very old and probably formed when spiral galaxies merged, more reasons to expect their central diffuse glow to resolve into really gigantic supermassive black holes.

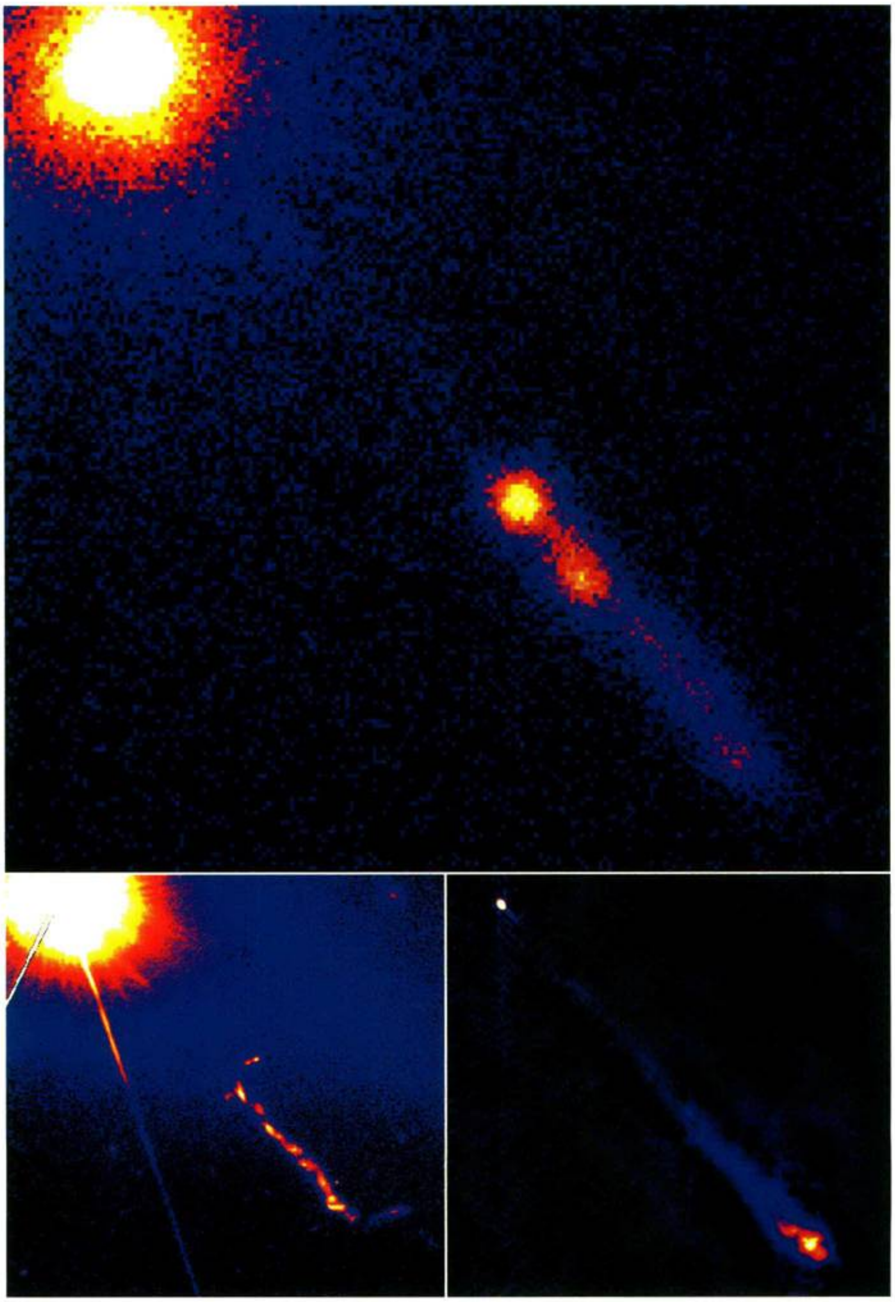
However, this hasn't been the case so far. Astronomer Richard Mushotzky has used Chandra to look at four of the nearest, brightest, and biggest elliptical galaxies — NGC 1399, NGC 1404, M49 (NGC 4472), and NGC 4636 — which should all have big supermassive black holes. Yet Chandra saw no evidence of a central supermassive object in any of them. Instead, a sampling of x-ray point sources appear scattered across the face of each galaxy, with a greater concentration near the center. If supermassive black holes exist there, they're doing an excellent job of hiding their presence.

Mushotzky believes that the x-ray point sources are either binary systems containing black holes, neutron stars, or white dwarfs in any number of combinations, or globular clusters that even Chandra can't resolve into individual systems. Interestingly, the existence of these objects implies that elliptical galaxies once harbored large numbers of massive stars, stars that pump out lots of complex, heavy atoms, such as iron and nitrogen, as they quickly evolve and die. Yet Chandra scientists have not found excessive quantities of complex atoms in these ellipticals, and the data suggest that the elemental make-up of these galaxies is remarkably similar to that of the Milky Way.

Meanwhile, the scientists remain puzzled by the lack of central supermassive black holes. Are the theories that predict these black holes wrong? And if not, what keeps the black holes at the center of these ellipticals from being visible in x rays?

CLOUDS EVERYWHERE

Besides viewing point sources, Chandra also has the ability to see the hot, diffuse gas that envelops galaxies. In Mushotzky's survey of four elliptical galaxies, he found that the gas in three of them matched the shape shown by starlight reasonably well. Yet NGC 4636 did not. Located about 50 million light-years from Earth in the rich Virgo Cluster, NGC 4636 looks like a big ball in optical light. In x rays, however, its clouds trace a spiral, streaming like a giant "S" from one end of the galaxy, through its center, and across to its



A powerful jet shoots from the quasar 3C 273, which lies at the upper left in all images. Surprisingly, the x-ray view (top) shows the jet brighter near the quasar, while in the optical (lower left) and radio (lower right) it appears very different. Top: NASA/CXC/SAO/H. Marshall, et al.; lower left: NASA/STScI; lower right: MERLIN

other side. Mushotzky marvels, "I haven't the faintest explanation for what process could cause this shape."

Several scientists have aimed Chandra at M84 and M86, giant elliptical galaxies lying close to one another in the core of the Virgo Cluster. As expected, Chandra showed both galaxies plowing their way through the hot gas that makes up the cluster's intergalactic medium. While the temperature of the gas inside both galaxies is about 10 million kelvins, the temperature of the Virgo Cluster's intergalactic medium soars to approximately 30 million kelvins.

What astonishes the astronomers, however, is the remarkable sharpness of the boundary between these hot and cold regions. In some cases, the transition zone measures less than 20,000 light-years across, a relatively small region considering the cluster spans millions of light-years. These sharp edges suggest to some scientists the presence of surprisingly large magnetic fields, which create a kind of surface tension that keeps the two clouds distinct and separate.

Furthermore, by laying Chandra's high-resolution x-ray images over earlier optical and radio images, astronomers are getting a much clearer picture of what's going on. In the case of M84, optical images show a round elliptical galaxy while radio images show two lobes extending north and south from the galaxy. Because previous x-ray images had revealed only a big blob of emission, scientists couldn't understand how the radio and optical images related.

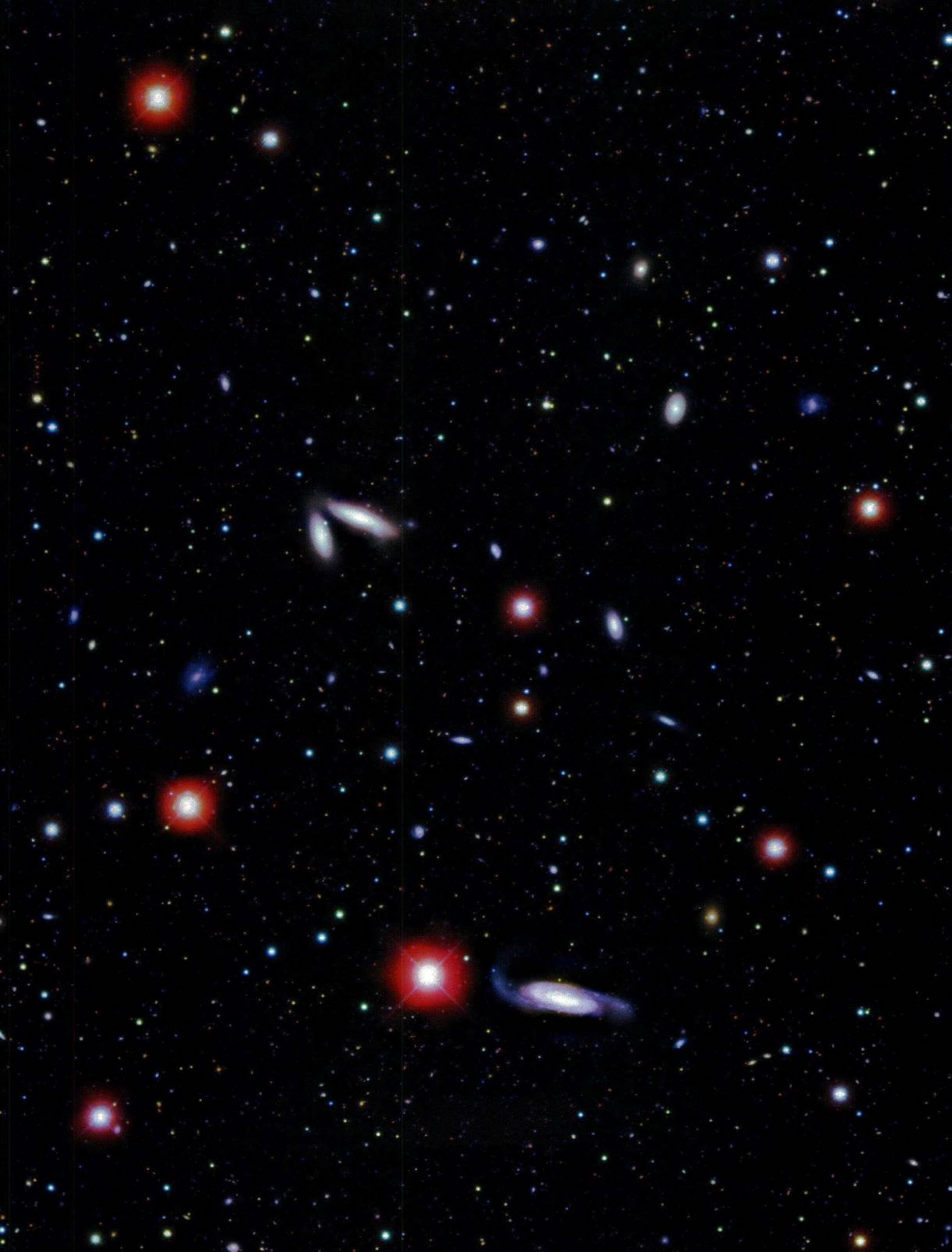
Now Chandra has resolved the x-ray blob into a gigantic h-shaped cloud that nicely fits around the two radio lobes. This fit tells scientists that the lobes are bubbles, and the h-shaped x-ray cloud is the shell of high-density material surrounding these cavities.

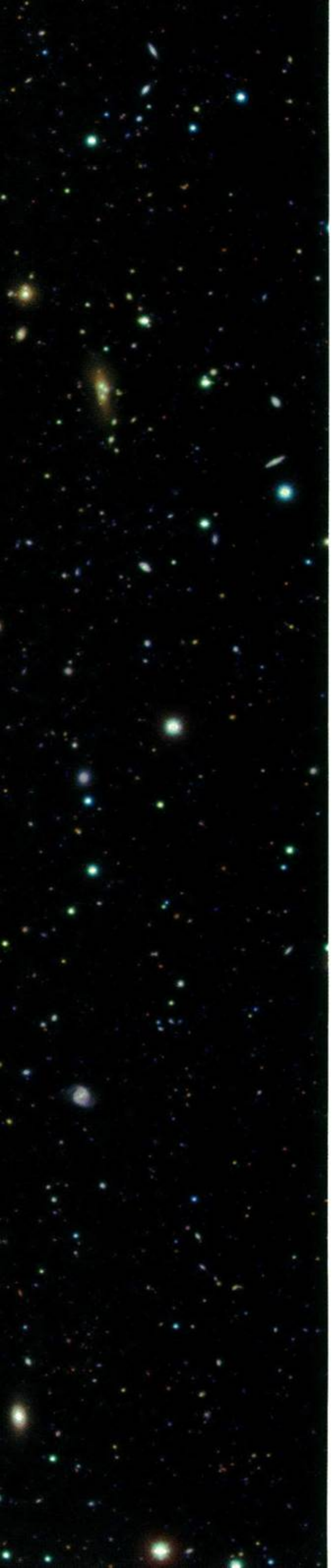
A WIDER VIEW

These early Chandra results, especially the wide-angle views of galaxies, furnish us the first glimpse at what surely will be a major shift in perspective. Using Chandra — along with the European Space Agency's orbiting x-ray telescope XMM-Newton, just now coming into full operation — scientists will soon be able to tally up the first population census of the x-ray objects inside galaxies. They will map the number and layout of each galaxy's black holes, neutron stars, and other bizarre objects, and see how these objects interact with one another. They will chart the interstellar and intergalactic gases that permeate and surround these galaxies. And they will apply this wider and more detailed view to refine their theories on the formation of galaxies and how these galaxies — and the universe itself — evolved into what we see today.

For the first time, we will be able to see galaxies as they truly are. And this new outlook will come from the host of additional discoveries and revelations still certain to pop out from Chandra's x-ray eye. All we need is time to see them unfold.

Robert Zimmerman, co-winner of the first David N. Schramm Award for High Energy Astrophysics Science Journalism, is a regular contributor to Astronomy. *His most recent book is* The Chronological Encyclopedia of Discoveries in Space, *published last year by Oryx Press.*





GOING DEEP FOR GALAXIES

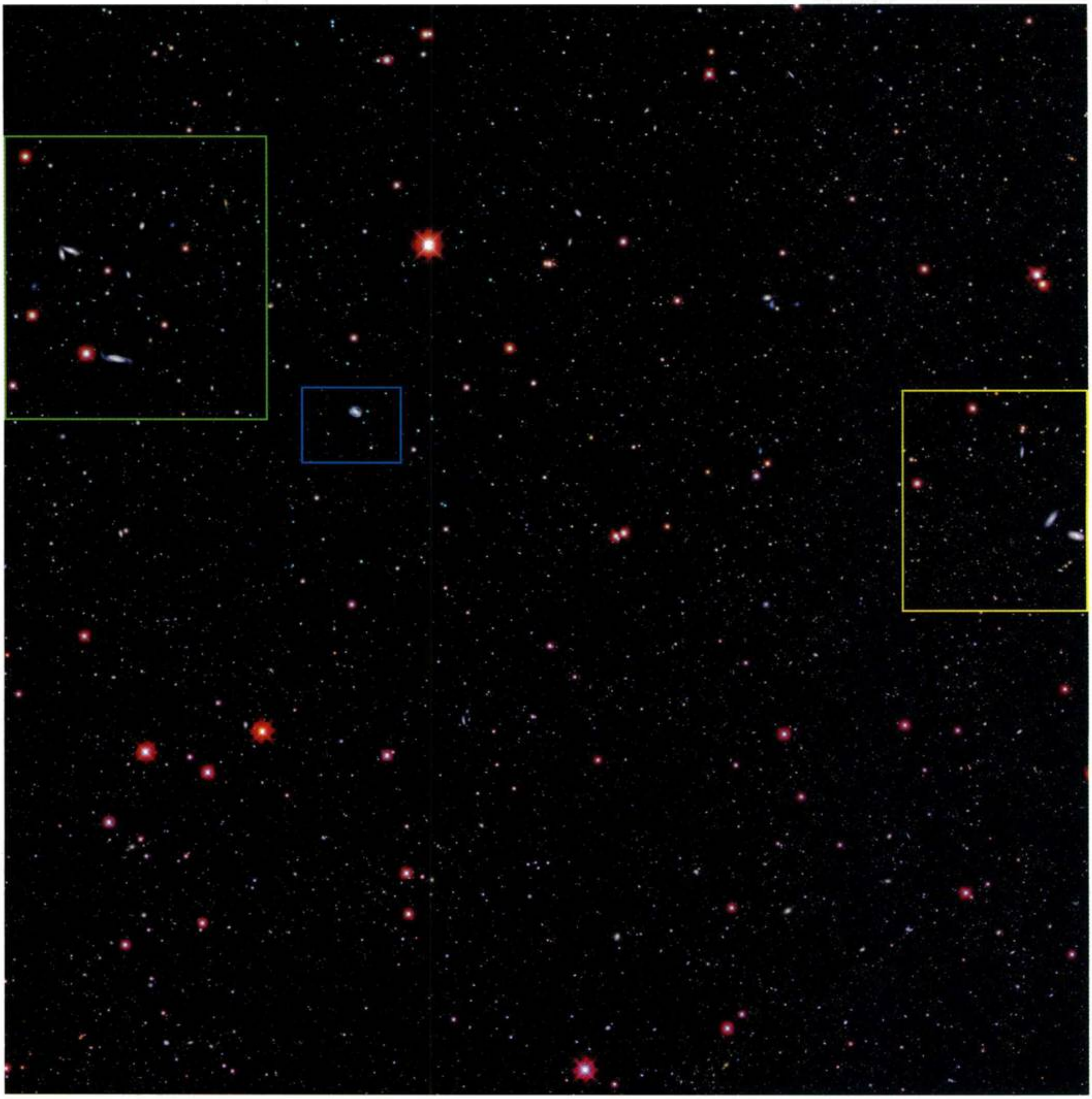
The NOAO Deep Wide-Field Survey promises to open up a whole new window on the distant universe.

by William Schomaker

Like intrepid explorers, astronomers are probing the farthest reaches of the universe in search of her most guarded treasure — the secrets of our origin. Unfortunately, truth doesn't come cheaply. And deciding where and how to search for these answers is no trivial endeavor, especially when the King's ransom is at stake.

Astronomical surveys — usually performed with dedicated telescopes probing the sky down to some faint, limiting magnitude — are celestial reconnaissance missions, designed to build a coherent picture and a complete database of astrophysical objects for a given area of the sky. Astronomers use these surveys to understand the dynamics and evolution of the universe as well as to select targets for the newest orbiting and ground-based observatories.

An expanded view of the premier NOAO Deep Wide-Field Survey (NDWFS) data release marks uncharted astronomical territory (see following page for full field). Thousands of faint stars and galaxies, including NGC 5646 near the bottom, highlight the diversity of the distant universe. The NDWFS will serve as a treasure map for astronomers seeking to understand how the universe began.



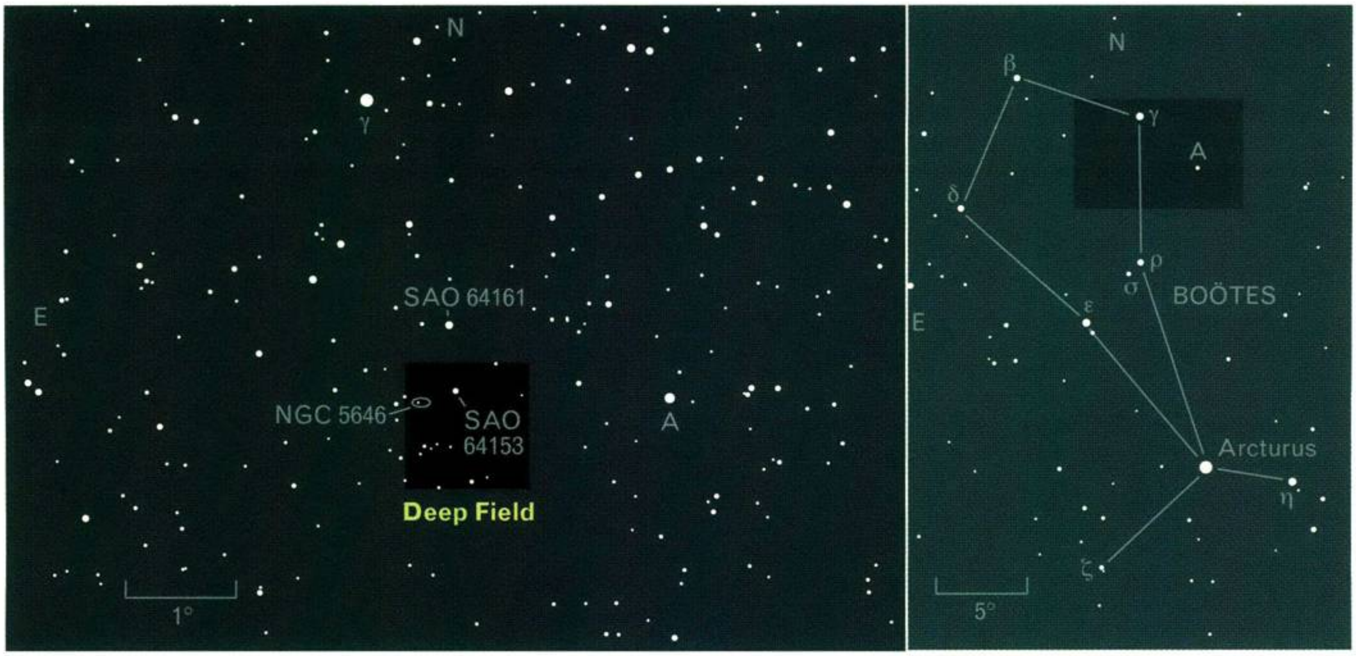
Green, blue, and yellow boxes highlight interesting sectors of the first NDWFS field, enlarged on the previous and following pages, respectively. At this time, the NDWFS is only 7 percent complete. By spring 2002, the NDWFS team expects to map 5 million faint galaxies through six different wavelength filters. Look for more images in issues to follow.

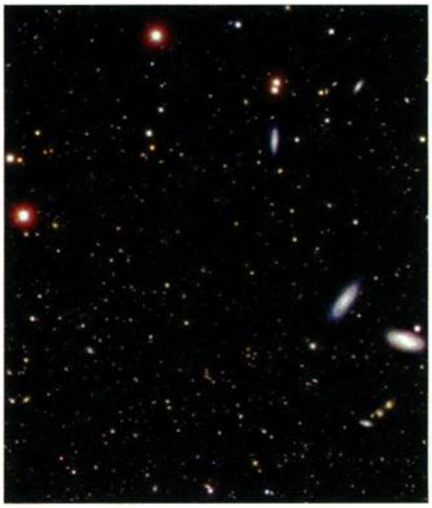
The Sloan Digital Sky Survey (SDSS) will produce a digital encyclopedia of the northern sky from Apache Point Observatory, near Sunspot, New Mexico. The Two-Micron All Sky Survey (2MASS) is scanning the sky in near-infrared wavelengths to help astronomers understand the invisible thermal glow of the universe. And now, thanks to the ongoing toil of 35 astronomers associated with the National Optical Astronomy Observatories (NOAO), observers will soon possess deep, optical and near-infrared treasure maps, reaching down to 26th and 21st magnitude, respectively.

At the 197th meeting of the American Astronomical Society in January, astronomers with the NOAO Deep Wide-Field Survey (NDWFS) team released the first block of data and images from this ambitious project to map two 9-square-degree patches of the sky — about 90 times the area of the full moon.

Peering perpendicular to the Milky Way's obscuring disk, the team hopes to image 5 million distant galaxies through three optical and three near-infrared filters. The designated search areas include a 3° by 3° patch of sky near the North Galactic Pole in the constellation Boötes and a 2° by 4.5° strip running through the constellation Cetus, roughly 30° from the South Galactic Pole.

Apart from providing a database of interesting targets for the twin 8.1-meter Gemini telescopes (Gemini





Covering slightly more than one square degree, the newly released NDWFS field lies in a small western portion of the constellation Boötes. It spans 900 times the area covered by the famous 1996 Hubble Deep Field.

North atop Mauna Kea on the big island of Hawaii and Gemini South at Cerro Pachón in central Chile), the team also hopes that the survey will help astronomers to understand the evolution of large-scale structures in the early universe by sampling a diverse set of deep, celestial objects.

"We are already discovering many distant galaxies and gaining new insights into their evolutionary history," says co-principal investigator Arjun Dey of NOAO. "Our initial results highlight one of the strengths of such deep, wide-field surveys: the ability to collect large numbers of rare objects — like very distant galaxies — and study how these populations of objects evolve."

The project, which began in 1997, combines optical and near-infrared observations from the 4-meter Blanco telescope at the Cerro Tololo Inter-American Observatory (CTIO) in Chile, with optical and near-infrared observations from the 4-meter Mayall telescope and the 2.1-meter KPNO telescope atop Kitt Peak in Arizona.

Among contemporary astronomical surveys, such as the SDSS, 2MASS, or Hubble Deep Field (HDF), the NDWFS holds a unique station: Upon completion it will venture fainter than wide, shallow surveys like the SDSS and 2MASS and cover 64,000 times the area of the celebrated HDF.

To maximize the scientific return of their survey, the NDWFS team plans to publicly release survey images and data immediately following retrieval and analysis. In addition, radio and x-ray observations of the survey fields are in the works. The team hopes to complete its survey by spring 2002. ■

William Schomaker is an associate editor for Astronomy.

Celebrating Ireland's Cosmic Ties

Milestones of the past highlight a trip through Irish astronomical sites.

by David J. Eicher

Astronomy is like no other science — its laboratory is open to one and all, professionals and amateurs alike, with the only requirement being a clear sky. This uniqueness has led to some really curious stories. One of those tales unfolded in a tiny village at the heart of Ireland during the mid-nineteenth century. In the history of a science filled with unlikely events, it's a standout.

As ironic as it may seem, some of the most important astronomical observations of the nineteenth century were made by an aristocratic politician named William Parsons. Born in 1800, Parsons was graduated from Oxford, became a member of the Irish Parliament, and by 1841 received the title Third Earl of Rosse, inhabiting Birr Castle, the principal structure of Birr (originally called Parsonstown, after the family). Even through his political rise, the Third Earl fostered a great love of sky observing that transformed

The 72-inch "Leviathan of Parsonstown" looks skyward again after more than a century in mothballs. Sean McGibbon

into an obsession. In his 20s, Parsons pursued his dream by teaching himself to polish speculum metal mirrors, and by 1827 he committed himself to huge, all-encompassing projects. After cutting his astronomical teeth on a 36-inch mirror, embarking on his maiden voyage of faint celestial objects, he soon longed for a larger instrument.

In 1845, at a cost of 30,000 pounds, Rosse completed his dream, a 72-inch reflector that was the largest telescope in the world. So amazing was this feat, creating a telescope with a mirror six feet across, that the telescope remained the largest until the completion of the 100-inch Hooker telescope at Mt. Wilson, California, in 1917. Armed with what became known as the "Leviathan of Parsonstown," Rosse commenced a rudderless voyage of discovery, using the instrument to observe many dozens of sky objects, noting the spiral structure of several "nebulae," and naming many now-familiar standbys held dearly by the amateur astronomy community — the Whirlpool Nebula (now known as the Whirlpool Galaxy), the Owl Nebula, and others.

Reviving Leviathan

On a cool Friday night in September 2000, Michael Murphy, David Bell, and fellow members of the Shannonside Astronomy Club set up their telescopes around the Leviathan of Parsonstown. Under a darkening twilight sky, the gentlemen commence their agreeable duty of hosting the Whirlpool Star Party, Ireland's largest annual event for amateur astronomers, a weekend of talks and observing that draws about 150 sky fans from the Emerald Isle, parts of the United Kingdom, and the United States.

The central focus this year is the restored 72-inch Rosse telescope, which has a new mirror and restored mechanics, making it operable for the first time since it fell into disrepair around 1890. The telescope, with its high-maintenance mirror, was always difficult and unwieldy to use. Lord Rosse constructed two 40-foot-high stone towers on either side of the giant telescope's tube; a windlass and chain enabled the telescope to be raised or lowered in altitude, and a circular iron arc attached to an azimuth beam allowed a small amount of movement in azimuth. Thus, the telescope was the great precursor to the Dobsonians that came 125 years later (although, with Rosse's version, an object could be followed across the sky for a little less than an hour at most).

To use his scope, Rosse had to climb into a wooden observer's cage that was subsequently hand-cranked over to the eyepiece position; upper wooden galleries were used for objects at high elevations. On top of the physical challenge of finding objects and using the telescope, the mirrors (there were two) were mostly bronze and were coated with nickel and then polished. This produced a crude reflective surface compared with a modern, aluminized glass mirror, and the corrosion on Rosse's mirrors occurred so quickly that they had to be swapped out and reworked every few days. The modern restoration of the 72-inch scope, begun in 1994 and initially completed in 1997, would bring the telescope back to life after more than a century.

Timely Reflections

Michael, a schoolteacher and expert amateur astronomer, walks me through the grounds of Birr Castle Demesne, still an operating estate after 380 years in the Parsons family. (A castle has stood on the site since 1170; the present structure was attacked in 1643 by Oliver Cromwell's English army and a cannonball still rests in the battlements.) The castle, telescope, and grounds now host a science center and museum, as well as many acres of lovely gardens and Irish landscape, that are open to the public. Birr, in County Offaly, is now a town of about 4,000 that is highly conscious of its past and astronomical connections. It seems an island, isolated from the frenetic pace of Dublin, 70 miles to the northeast, or the thriving suburbs of Limerick, 50 miles southwest.

There's something magical about viewing objects through telescopes set up beside the Leviathan, of seeing the Whirlpool Galaxy from the very spot where it was first named. Brilliant lights from a BBC television crew illuminate the telescope structure at intervals, momentarily interrupting observing but creating a surreal view of the famed instrument. There's a bustle of activity as muted voices of the hundred people on the castle property chat about their targets; my mind drifts back a century and a half to Rosse's days on the grounds.

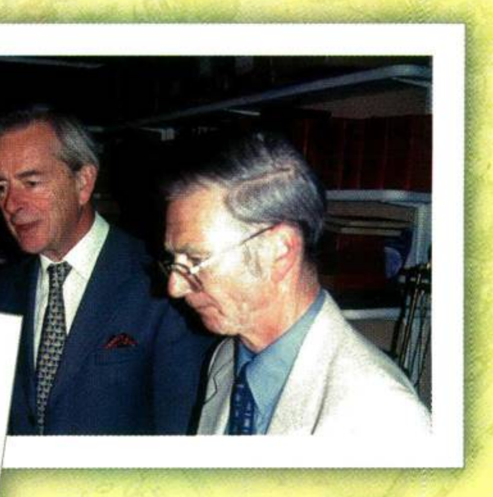
Any telescope reflects the mechanics of the age in which it was built. With the Hooker telescope, its riveted joints, giant bolts, and steel cage bring to mind a World War I battleship. Rosse's Leviathan, however, instantly conveys the iron, chain, and track of a mid-nineteenth-century locomotive. The massive tube, which spans 54 feet and weighs 12 tons, appears for all the world like a giant boiler. Rosse's ingenuity, particularly given his semi-isolation from the Industrial Revolution, placed him ahead of his time. This worked as an advantage, in that he found, cataloged, and described many objects (including the Messier catalog) in much more detail than his predecessors had. In a sense, he was the last great purely visual observer. But it was also a disadvantage: He was too far ahead of the birth of astrophysics and the explosion of photography and spectroscopy to fully understand the objects he was seeing.

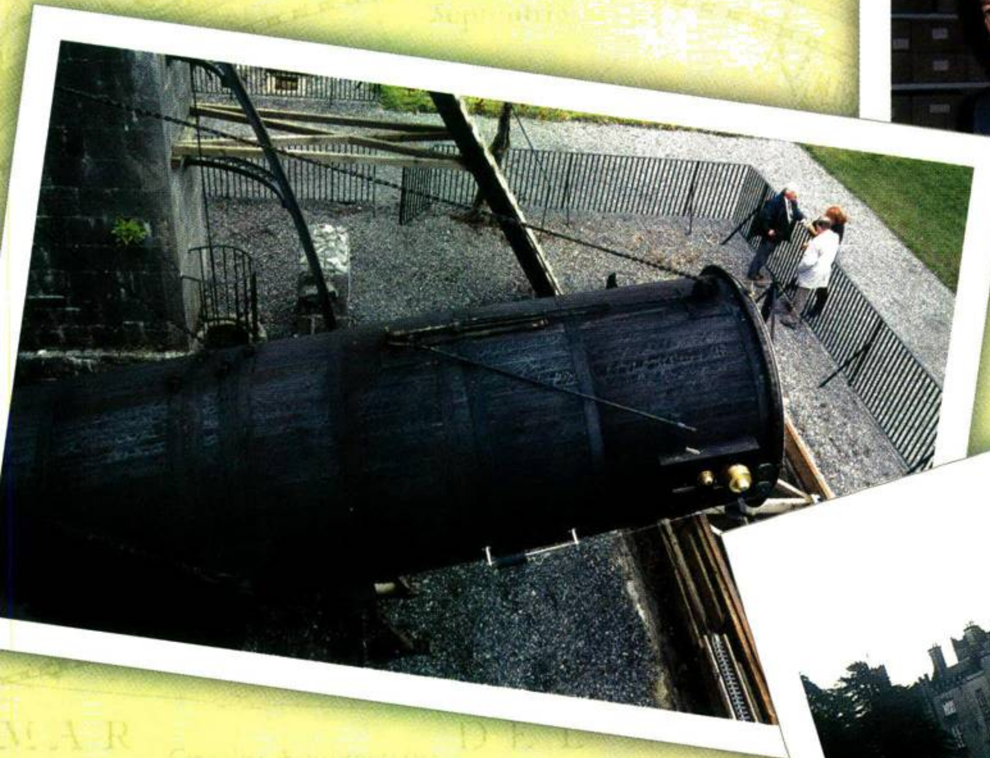
The following day I accompany David Whitehouse and the BBC crew back to the castle to shoot some footage for *Final Frontier,* a British science program, and then we all tag along into the castle for more footage. Our host is William Brendan Parsons, Seventh Earl of Rosse, the great-great-grandson of the famous astronomer. Within the castle's archive, we are presented with spectacular artifacts; Rosse's original drawings of the Whirlpool Galaxy, the Dumbbell Nebula, the Ring Nebula, and M101, to name a few. There are many autograph letters to and from Rosse between the astronomical greats of the day, John Herschel, Charles Piazzi Smyth, and others. The guest logbook for the observatory includes an opening page inscription, made in 1845 by Charles Babbage, the founder of modern computing and data analysis.

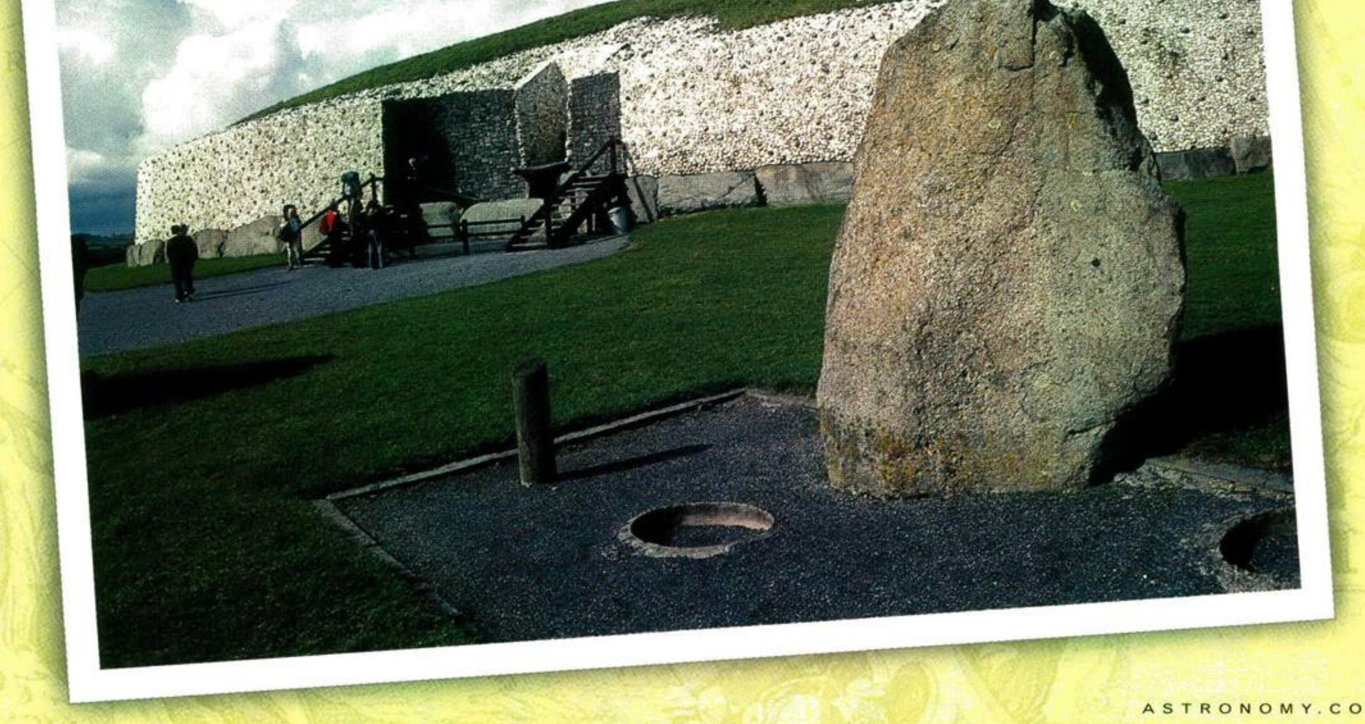
Thanking Lord Rosse, we proceed back to the present century and the Whirlpool meeting, held at the County Arms Hotel on the edge of town. I am privileged to address the meeting, speaking about my impressions of Rosse and how, all these years later, 20th-century Dobsonian users paralleled his voyage of discovery. John Brown, the Astronomer

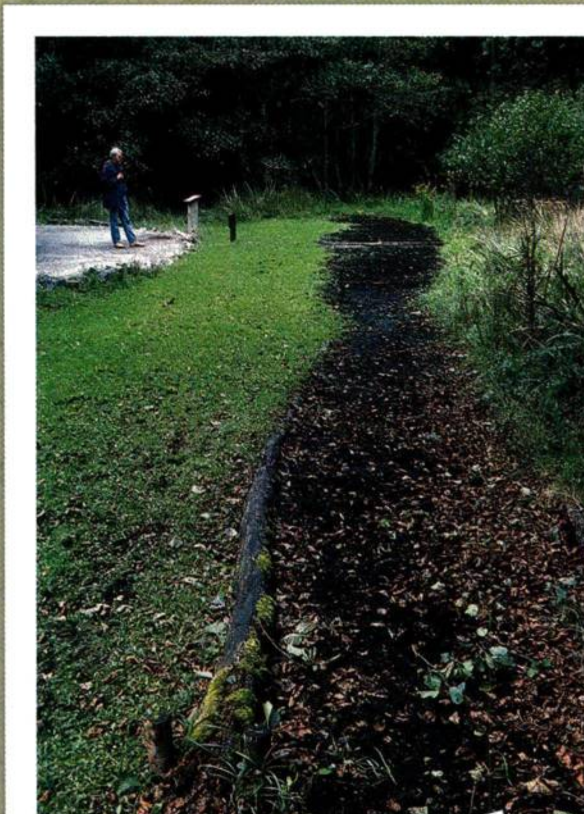
Clockwise, from top left: The refurbished tube of the Rosse telescope congers up memories of a mid-nineteenth-century steam locomotive boiler; the Seventh Earl of Rosse, great-great-grandson of the famed astronomer (left), welcomes visitors; Birr Castle was attacked by Oliver Cromwell; Newgrange, northwest of Dublin, is one of the great neolithic burial sites in Europe, predating the Giza pyramids by 500 years.

All photos on the following pages by *Astronomy:* David J. Eicher



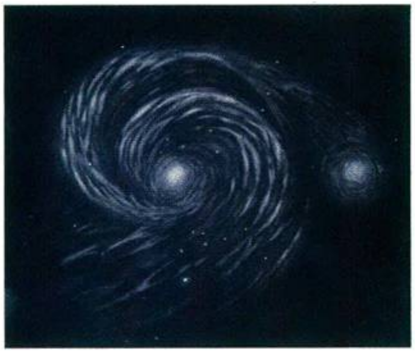






How Lord Rosse Saw It

William Parsons, Third Earl of Rosse (1800–1867), discovered the spiral nature of galaxies (though he didn't realize what they were) and named many now-familiar objects such as the Whirlpool Galaxy and the Owl Nebula. He is a storied figure among deep-sky observers more than a century after his death. Excerpts from his notes on well-known objects, made with the 72-inch "Leviathan of Parsonstown," follow.



Whirlpool Galaxy sketch by Lord Rosse; photo by *Astronomy*: David J. Eicher

The Whirlpool Galaxy (M51): "Spiral convolutions . . . with successive increase of optical power, the structure has become more complicated. . . . The connection of the companion with the greater nebula is not to be doubted. . . . the most conspicuous of the spiral class."

The Hercules Cluster (M13): "A cluster; stars small and very close together."

The Dumbbell Nebula (M27): "Not actually resolvable but symptoms of it. The 6-foot (diam.) reflector surrounds it with an external ring like a chemical retort."

The Pinwheel Galaxy (M33): "Full of knots. Spiral arrangement. Two similar curves like an 'S' cross in the centre."

The Ring Nebula (M57): "Evident symptoms of resolvability at its minor axis: strips or wisps inside and regularity of outline broken by appendages branching into space, especially in minor axis."

The Owl Nebula (M97): "Two stars considerably apart in the central region; dark penumbra around each spiral arrangement. (On many occasions only one star seen and spiral form doubtful.)"

Royal for Scotland, delivers a sensational summation of the current knowledge of black holes and worm holes, aided by good humor and a magician's set of props. Astronomy author Neil Bone describes his contention that the next couple of years will bring memorable shows of aurorae. Julian Barbour, author of *The End of Time*, delivers an intriguing paper on how we view time in the universe. After three days of observing, history, talks, and visiting over nice dinners, we go our separate ways into the Irish countryside.

In the end, a little disappointment washes over some of the participants as the telescope director at Birr does not open the Leviathan for observing. The mirror has a coating problem. There are concerns about someone falling off the stone piers in the dark. Perhaps they'll open it next year.

Tapping Historical Roots

We travel south to Limerick and spend a joyous evening at a medieval banquet at Bunratty Castle in County Clare, one of the most impressive Irish castles, built in 1425, which now hosts the somewhat touristy banquet. Amid the courses of soup, pork and chicken, potatoes, bread, and vegetables — each of which has to be eaten by hand, assisted only by a sharp dagger — the Whirlpool Star Party is declared a success by its organizers. Bunratty launches us into an explorative mode in which David Bell and I find other Irish links to the past.

At Craggaunowen, north of Bunratty, we walk through an outdoor museum highlighting the Celtic and Viking past that includes a neolithic trackway, burial tombs, and later ringforts. In Limerick, King John's Castle (built 1200–10) demonstrates a superb historic fortification on the River Shannon, in an attractive town now associated with Frank McCourt's *Angela's Ashes* and the rock group The Cranberries. Traversing the Irish countryside, which is made somewhat hazardous due to narrow, twisting country roads with hedgerows protruding out into them, brings this modern explorer to other sites of interest — Trim Castle in County Meath (built in 1176); the Rock of Cashel in County Tipperary, a defensive fortress given to the church in 1101 and site of St. Patrick's Cross; and the Book of Kells, the celebrated 9th-century illuminated gospel manuscript at Trinity College in Dublin, alongside the River Liffey.

Northwest of Dublin I encounter the greatest archaeoastronomical site in Ireland, Newgrange. The passage tomb at Newgrange Farm, the largest of several in the area, dates to more than 5,000 years ago, predating the Giza pyramids by at least 500 years. Constructed atop an impressive hill, the tomb represented a gargantuan project for the neolithic farmers who built it.

Covering more than an acre of ground, standing more than 30 feet high, and consisting of more than 200,000 tons of stone and earth, Newgrange holds a central room with a spectacular corbeled roof protecting sacred stones. It is the oldest room in Europe and contains finely scrolled graffiti more than 500 years old. In the darkness of the room, stone-age peoples carried the cremated remains of their ancestors and placed them onto treasured rock surfaces.

Once per year, on the winter solstice, a shaft of sunlight sliced down the horizontal tunnel, illuminating the bones and carrying the spirits of their dead into the afterlife. In such an alignment with cosmic meaning, astronomy was alive and well in Ireland many centuries before Lord Rosse arrived on the scene. Rosse's meaningful explorations, his ambition and drive to put science and knowledge on par or ahead of his politics, sets a lofty example for all of us to remember. ■

Clockwise, from top left: David Bell observes the remnants of a neolithic trackway at Craggaunowen; medieval supper at Bunratty Castle with Bell (left) and Michael Murphy (right) includes authentic cuisine; the entrance stone at Newgrange exhibits mysterious Celtic patterns made 5,000 years ago; Trim Castle, in County Meath, offers a spectacular view of a 12th-century structure that also served as backdrop for Mel Gibson's popular film *Braveheart*.

Dave Eicher is managing editor of Astronomy. *He has been observing deep-sky objects for 25 years. This was his first trip to the Emerald Isle.*

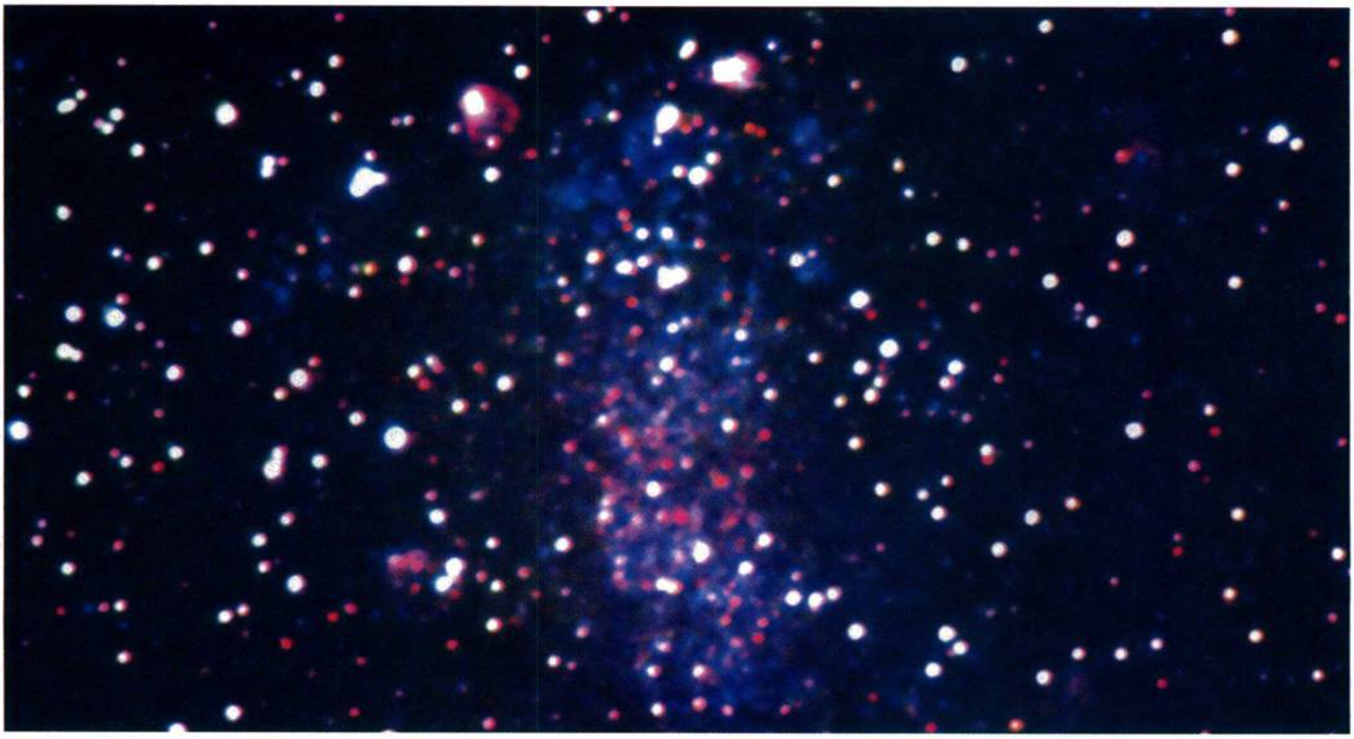
The Man Who Tracked NEBULAE

Astronomer Edward E. Barnard discovered more than 300 nebulae, including one he found as a young amateur that helped revolutionize cosmology.

by Richard Jakiel

The annals of observational astronomy brim with fierce debates, iconoclastic observers, and obscure details. Such is the case of Barnard's Galaxy. Originally described as a "nebula" by a one-time poverty-stricken photographer's assistant, it was later described in a landmark 1925 paper by American astronomer Edwin Hubble as "the first object definitely assigned to a region outside the galactic region." Hubble wrote prosaically that the irregular galaxy about 1.8 million light-years from Earth "may serve as a stepping-stone for speculations concerning the habitats of space beyond." In other words, galaxies exist beyond the Milky Way. Many amateurs ignore this challenging deep-sky object in Sagittarius, but it has special meaning to all of us. It is our link to Edward E. Barnard, who discovered the galaxy in 1884, at age 26, with a 5-inch refractor.

Barnard poses by the Lick Observatory's 36-inch refractor after his 1892 discovery of the fifth satellite of Jupiter. Mary Lea Shane Archives of the Lick Observatory, University of California at Santa Cruz



NGC 6822, Barnard's Galaxy, is a challenging object for amateur astronomers.

James R. Foster

Barnard is famous for overcoming an impoverished childhood to discover 16 comets, Jupiter's fifth satellite (Amalthea), the California and Rosette nebulae, and more than 300 dark nebulae. Barnard also pioneered wide-field astrophotography (he made the first photographic discovery of a comet in 1892) and many of his photographs of dark nebulae were included in his *Atlas of Selected Regions of the Milky Way*.

An Astronomer Meets a Galaxy

Barnard once estimated that he had observed every astronomical object possibly visible to him at least 100 times. He became a devoted comet hunter after Rochester, New York, businessman H. H. Warner offered in 1881 to pay $200 for the discovery of each comet. "Barnard's method was to sweep the telescope sequentially across horizontal zones of sky," writes William Sheehan in *The Immortal Fire Within: The Life and Work of Edward Emerson Barnard*. "With the completion of one sweep, he raised the telescope slightly and began a new sweep of a zone partially overlapping the first." Barnard himself wrote that the sweeps, "if plotted on a piece of paper, would resemble in length, breadth, and overlapping, the weather-boarded side of a house."

Barnard often worked dusk to dawn, seven days a week. He lost at least one hat to high winds on mountaintops. On January 2, 1885, using his 5-inch refractor, Barnard demonstrated his incredible eyesight. He spotted Comet Encke, which Princeton University's C. A. Young had seen two weeks earlier with a 23-inch refractor. "It was very faint in the 23-inch, and I could not see it at all in the 9½-inch," Young wrote in a letter commending Barnard's acute eyesight.

Born in the slums of Nashville, Tennessee, in 1857, Barnard would often lie in an old wagon bed to watch the stars, even when the artillery fire of the Civil War boomed nearby. The pastime "helped to soften the sadness of my childhood," Barnard once told an audience. Although he was intelligent, Barnard received only two months of formal schooling. At age 9, he began working in a Nashville photographic studio, where he remained employed for 17 years. He educated himself with the used books he purchased. He bought his 5-inch refractor in 1876 with the equivalent of eight months' salary. In 1881, he used the telescope to discover his first comet, and his reputation grew with each additional discovery. In 1883, his colleagues in Nashville raised enough money for a fellowship to Vanderbilt University, where Barnard studied and worked as a part-time instructor. He spent virtually every clear night observing at Vanderbilt, often using the university's 6-inch refractor.

An Elusive Nebula

While sweeping for comets on August 17, 1884, Barnard stopped at an uncataloged nebula in Sagittarius. He described it as "an excessively faint nebula in the field and south of the bright planetary nebula no. 4510 of Herschel's *General Catalogue* (*GC*)." The galaxy which now bears his name was "some 2' in diameter, and very diffuse," Barnard wrote. A year later he again examined the nebula with Vanderbilt's 6-inch telescope and a wide-field eyepiece that boosted its visibility. "If it had always been as large and bright as now," he wrote, "I cannot conceive how it could have been missed by observers when examining GC 4510. Probably this is a variable nebula."

By the time Barnard graduated from Vanderbilt in 1887 with a bachelor's degree in mathematics, he had discovered eight comets. He used $1,600 of Warner prize money to pay for a "comet house" for his bride, Rhoda Calvert. In 1888, he took a job at the Lick Observatory near San Jose, California, and used his knowledge of photography to improvise a crude, wooden box camera for the observatory's 36-inch refractor. By photographing known comets, he demonstrated that comets could be tracked photographically over time.

Barnard's Hard-To-Find 'Nebula'

Barnard took hundreds of wide-field photographs of the Milky Way. Many of them revealed large "starless tracks," areas of dark, obscuring matter — dark nebulae. Although NGC 6822 has a visual magnitude of 9.3, its light is spread over an area 15.5' by 13.5'. Experienced observers know that low-power high-contrast fields are required to visually confirm such a diffuse object. However, in the late 19th century the instruments of choice were refractors with long focal lengths and narrow, restrictive fields. Observers of the day did not have access to wide-apparent-field, high-contrast eyepieces. In other words, they were ill-equipped to find large, low-surface-brightness objects such as Barnard's Galaxy.

In 1847 and again in 1864, Sir John Herschel produced the *General Catalogue* of known deep-sky objects. Most of the more than 5,000 entries were made by Herschel and his father, William. During the next two decades, William Lassell, Lewis Swift, and others discovered thousands of new objects. A new catalog was needed to list them, so the Danish astronomer John L. E. Dreyer compiled the *New General Catalogue* (*NGC*).

Observatories across North America and Europe were asked to verify the NGC entries. In 1887, astronomers at the University of Virginia in Charlottesville used the 26-inch refractor at the Leander McCormick Observatory on campus to examine the region of sky with Barnard's Galaxy. Unfortunately, the high magnifications and restrictive field of the telescope made it inadequate for observing such a large, low-surface-brightness "nebula." Astronomers at the observatory missed the galaxy completely. Instead, they noted two bright regions of ionized hydrogen gas (H II regions) located on the northern end of the galaxy. The brighter of the two regions was assumed to be Barnard's NGC 6822.

Other observers fared no better. H.A. Holden, using a 20-inch refractor, was only to spot the brighter of the two H II regions and missed the main part of the galaxy. He noted that NGC 6822 was "very small" instead of "large," as described by Barnard. In France, Guillaume Bigourdan tried his luck using a 12-inch refractor. One of the last great visual observers, he is best known for measuring extremely accurate positions of nebulae, but he missed Barnard's nebula entirely.

Dreyer retained Barnard's original description of "very faint, large, elongate, diffuse" nebula perhaps on faith of his legendary observing skill; however, the object's status was far from certain. This uncertain state of affairs was common at the time. Meanwhile, observations of many other nebulae continued to pour in. The steady stream of discoveries became a torrent when observatories began using photography. Astronomers discovered thousands of new nebulae, including many of the curious "spiral" forms. Dreyer compiled two *Index Catalogues* (*IC*) to keep up with the glut of discoveries. The fainter H II region in the vicinity of Barnard's Galaxy was eventually designated IC 1308.

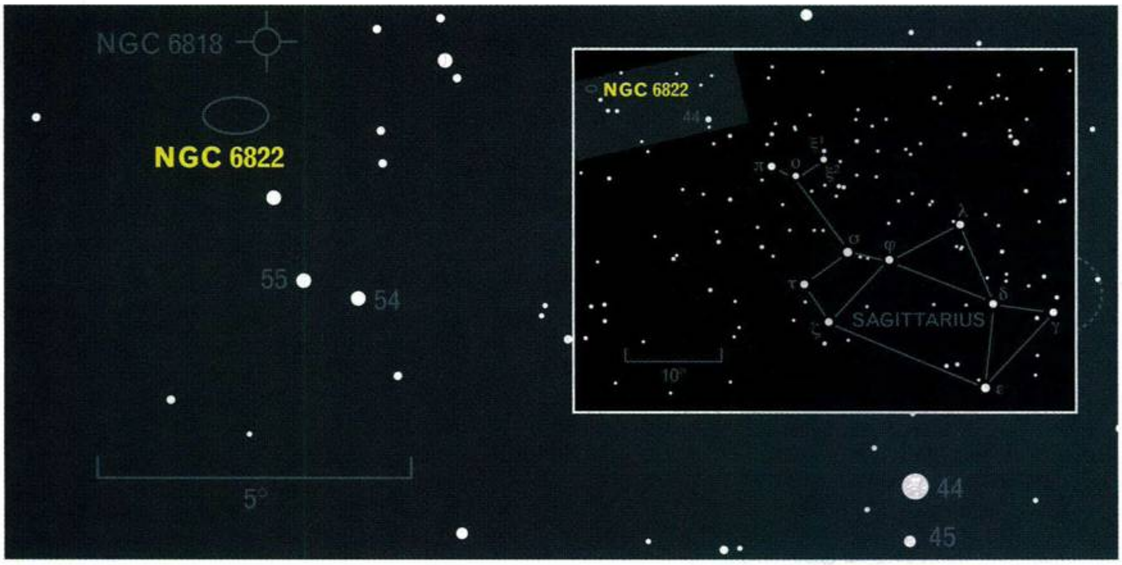
Astrophotography Comes of Age

During the late 1800s and early 1900s, Barnard stood at the division between old and new and stepped across. While he was one of the best visual observers in the world, he also became a pioneer of wide-field astrophotography.

While he worked at the Lick Observatory, its board of regents purchased a 6-inch lens, described by Sheehan and Lick Observatory astronomer and author Donald Osterbrock as "the type known to opticians as a Petzval doublet — a two-lens system of which each lens was itself an achromatic doublet." This lens became known as the Willard lens, named after a California photographic-stock dealer. Viennese mathematician Josef M. Petzval had developed the fast lens for the slow speeds of daguerreotype photography. This type of wet-plate photography required a great quantity of light to give a sharp image. For this reason, portrait studios used the large, short-focus Petzval lenses to lessen the time of sitting.

Two possible asteroids, right of Barnard's Galaxy, sneak into this time-exposure image.

Chuck Vaughn



With the Willard lens, Barnard took breathtaking views of the Milky Way.

In 1896, Barnard moved to a house built adjacent to the University of Chicago's Yerkes Observatory on a flat plain several hundred feet above the shore of Lake Geneva, Wisconsin. (It was then that he was awarded the Gold Medal of the Royal Astronomical Society.) One of Barnard's chief rivals was Max Wolf of the Heidelberg Observatory in Germany. He used a 5¼-inch portrait lens to discover the North America Nebula (NGC 7000), dark nebulae in the Milky Way, and more than 5,000 "nuclear nebulae" (galaxies). While Barnard tried to acquire a 10-inch Bruce lens, Wolf had received two 16-inch Bruce lenses, which were coaxially mounted with a 10-inch refractor. The lenses were named after Catherine Wolfe Bruce, a well-known New York heiress and generous benefactor of many astronomical projects.

Even photography did not quickly resolve the discrepancies between Barnard's original observations and those made with much larger telescopes. In 1906 and 1907, Wolf used his 16-inch Bruce cameras with a 28½-inch reflector to photograph the region around NGC 6822. He identified the two largest diffuse nebulae as NGC 6822 and IC 1308, while Wolf also noted a "dense region of small clusters and nebulae." Wolf's new object actually was the main bar of the galaxy, now resolved into stars and nebulae. It received the designation IC 4895, and once again Barnard's original observations were overlooked. It would take another 15 years to uncover its true identity.

One of many extremely hot stars in Barnard's Galaxy blasts its surroundings with intense winds, producing this bubble nebula.

Anglo-Australian Observatory

The Great Debate

Since the discovery of "spiral nebulae" by the Irish observer William Parsons in 1845, these objects had baffled astronomers. By the early 20th century, the number of known nebulae was in the thousands. Astronomers wondered if spiral nebulae were part of the Milky Way, or separate "island universes" far beyond.

In 1920, the National Academy of Sciences sponsored the "Great Debate" in Washington, D.C. to help resolve this issue. Many astronomers supported Heber D. Curtis of the Lick Observatory. He proposed that the Milky Way was relatively small, no more than 15,000 light-years in diameter, with the sun located near its center. He estimated that a million or more "spiral nebulae" were actually "island universes" located at vast distances from our galaxy.

Harlow Shapley, of the Mt. Wilson Observatory outside Pasadena, California, represented the single-system hypothesis. He argued that the spiral nebulae were within the Milky Way, and proposed that the Milky Way was a gigantic system 300,000 light-years across, with the sun at least 50,000 light-years from its center. (The disk of the Milky Way actually extends 50,000 light-years from the center of the galaxy, and the sun is about halfway out from the center.)

Though neither Curtis nor Shapley won the debate, Hubble, of the Mt. Wilson Observatory, sided with Curtis. In 1920, Hubble and other astronomers began to photograph the larger, brighter spirals. Meanwhile, Charles D. Perrine of the Cordoba Observatory in Argentina studied southern galaxies using a 30-inch reflector. He found that Barnard's "diffuse nebulae" and Max Wolf's "small clusters" were part of the same system. Perrine classified NGC 6822 as a Magellanic Cloud-type object. This helped clear the way for Hubble's groundbreaking work in 1925.

Resolution: Hubble's 1925 Paper

Hubble was a University of Chicago graduate student at Yerkes from 1914 to 1917, when he earned his Ph.D. He volunteered in the Army to fight in World War I, and was hired at Mt. Wilson after the war. Using the 100-inch telescope at Mt. Wilson, Hubble conducted a detailed study of the structure and stellar population of Barnard's Galaxy. He discovered 15 variable stars, 11 of which were Cepheid variables. These very luminous yellow supergiants were keys that unlocked the mystery of the universe to Hubble.

Early in the 20th century, Henrietta Swan Leavitt discovered a linear relationship between the period of pulsation of Cepheids and their luminosity. This gave Shapley, Hubble, and others the "standard candles" required for them to generate galactic and intergalactic yardsticks.

Hubble's discovery of eleven Cepheid variables in Barnard's Galaxy was one of the most important milestones in galactic astronomy. His landmark 1925 paper, "NGC 6822, a Remote Stellar System," published in *The Astrophysical Journal*, is one of the great classical studies of early 20th-century astronomy. (It was published two years after Barnard's death.) Using Leavitt's period-luminosity relationship, Hubble determined the distance to Barnard's Galaxy. He quickly followed suit with the nearby spirals M31, which is 2.2 million light-years away, and M33, which is about 3 million light-years away. Hubble's observations of NGC 6822 helped resolve the "Great Debate" and redefined the distance scale of the universe. With this insight it would soon become clear that spiral nebulae were galaxies far beyond our own.

Today, NGC 6822 is again under intense scrutiny by astronomers using the Hubble Space Telescope and ground-based observatories to study the formation of globular clusters. NGC 6822 has also gradually emerged from relative obscurity to become a target for amateur telescopes. Amateurs have observed Barnard's Galaxy with instruments as small as 7x35mm binoculars, and its brightest stars and nebulae can be seen with today's large telescopes. Several of its largest H II regions are bright enough to be visible in the northern part of the galaxy.

Although Barnard's Galaxy may never be a star-party favorite like the bright galaxies M31 or M51, it deserves our attention. So, take some time to observe this historically significant galaxy. Few such revolutionary objects have risen from such a humble past, like Barnard himself. ■

Richard Jakiel, a chemist living in Atlanta, Georgia, is an amateur astronomer who specializes in the observation and historical study of galaxies.

NGC 6822 is about 1.8 million light-years away. Large telescopes can resolve the galaxy's brightest stars, but even smaller telescopes can pick out these two clouds of glowing gas, seen here at one end of a dim bar.

Anglo-Australian Observatory, David Malin

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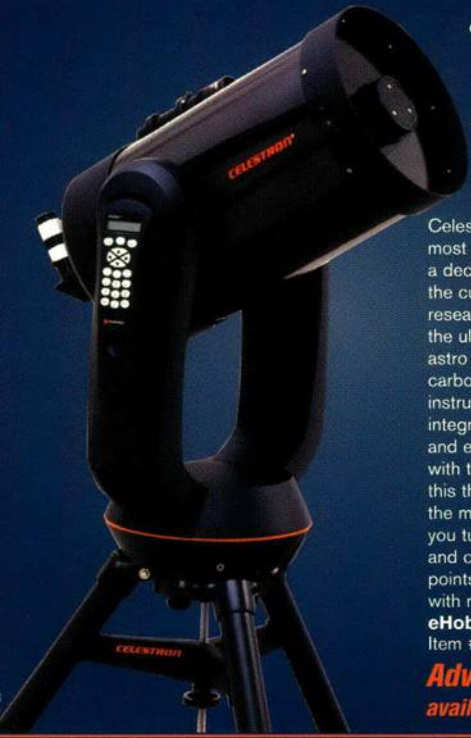

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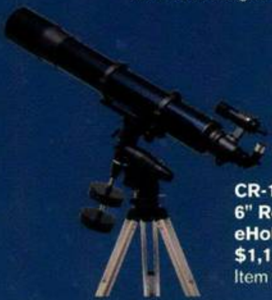

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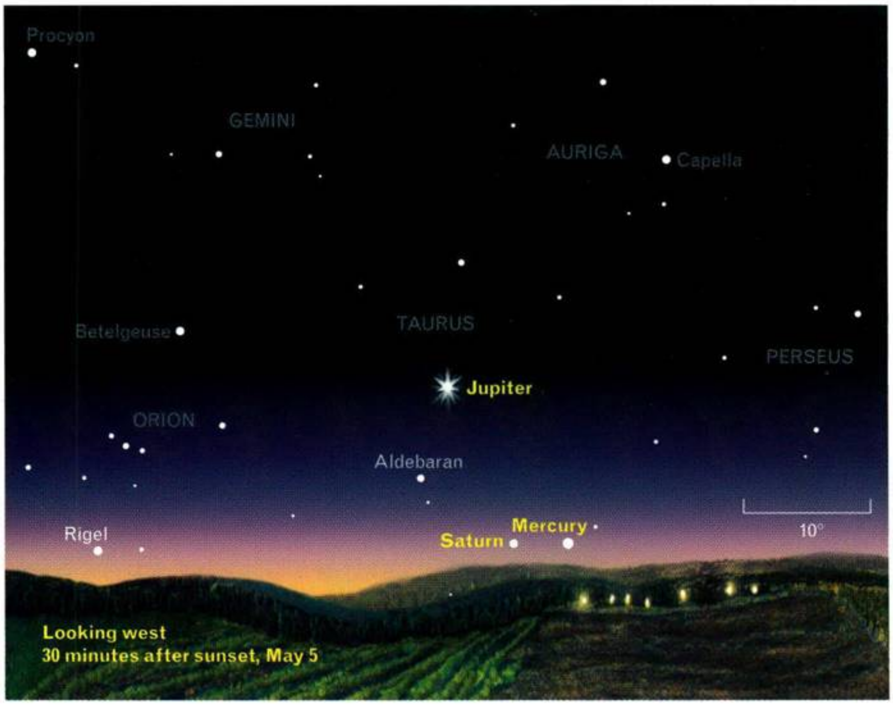
sky Show

may

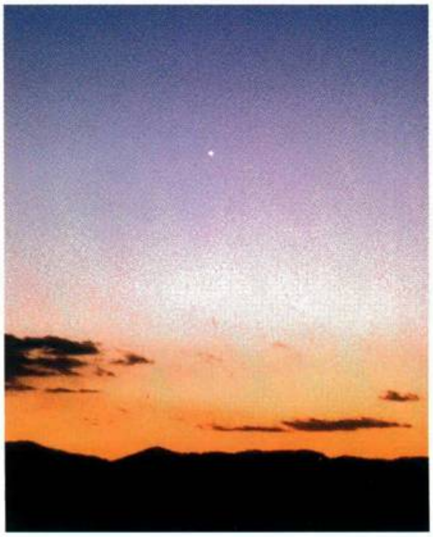
The Red Planet comes on strong amidst a show from elusive Mercury.

by Martin Ratcliffe and Alister Ling



Looking west
30 minutes after sunset, May 5

Mercury makes an evening appearance on March 29, 1997 (right). Enrico Montanari



▶ The swiftest planet vaults into prominence when Mercury climbs out of the evening twilight to pass Saturn and Jupiter. You'll never have an easier time spotting the innermost planet. Without signposts, it can be tricky to recognize, but this time it is a full magnitude brighter than Saturn. Follow Mercury as it glides past both the Ringed Planet and Jupiter on its way up to maximum elongation from the sun on the 22nd. By the time the crescent moon slides past on the 24th, Mercury is already fading back into the twilight's glow.

Jupiter and Saturn are disappearing for another season but will return in a vengeance of activity. The moon occults, or covers up, Jupiter on the afternoon of August 15th and then Saturn on the morning of September 10th. Mark your calendar. More occultations follow later in the year.

Mars rises into prominence in the southeast during the late evening. Next month it rises at sunset. This is opposition, when it hits peak brightness and is biggest in the eyepiece. Already Mars glows brightly at magnitude –1.4 but next month it will really blaze, reaching magnitude –2.4, brighter than Jupiter.

Why does Mars brighten so much? Why hasn't it been this bright for ages? Firstly, Mars is gradually approaching its closest point to the sun, and the closer an object is to our central luminary, the more light it reflects. More importantly, Earth and Mars haven't been closer since 1988. Together, these factors create a great display. Mars will be even brighter and closer the next time around, in August 2003.

Make sure you take advantage of those balmy, hazy nights that show up at this time of year. These conditions generally mean that our atmosphere is barely moving, and that's exactly what you need in order to see fine detail on Mars's surface. Because Mars is so low in our sky, as seen from the Northern Hemisphere, its light has to pass through more of Earth's turbulent atmosphere than usual, increasing chances of a blurry view. A poetic night filled with twinkling stars means detail-destroying turbulence.

Another rule of observing is that the more you do it, the more detail you'll see. Whether it's fine martian details you're after, or dust tails in Comet 24P/Schaumasse, or detecting tiny Pluto in a small scope, only eyepiece time can give you the experience to make the most of what the sky has to offer.

What color is Mars, anyway? It's certainly not traffic-light red, and many people see shades of orange. What do you see? When a full-blown dust storm breaks out, Mars is noticeably more beige. If you're wondering where the real red objects are, try our selection of springtime ruby-hued variable stars. Find out which ones are redder than the Red Planet.

2001 May

1 The moon is at perigee (229,547 miles from Earth), 11:41 P.M. EDT

4 Venus is at greatest brilliancy (magnitude –4.5), 2 P.M. EDT
Eta Aquarid meteor shower peaks (page 68)

6 Asteroid Ariadne is at opposition, 8 P.M. EDT

7 Full moon is at 9:52 A.M. EDT
Mercury passes 4° north of Saturn,1 P.M. EDT

8 Asteroid Iris is at opposition, midnight EDT

10 The moon passes 1.9° north of Mars, 3 P.M. EDT

11 Mars is stationary, 11 A.M. EDT

12 Mercury passes 8° north of Aldebaran, 6 A.M. EDT

13 The moon passes 3° south of Neptune, 8 P.M. EDT

14 The moon is at apogee (251,124 miles from Earth), 9:30 P.M. EDT

15 The moon passes 3° south of Uranus, 4 A.M. EDT
Last quarter moon is at 6:11 A.M. EDT

16 Mercury passes 3° north of Jupiter, 1 P.M. EDT

19 The moon passes 4° south of Venus, 5 A.M. EDT

20 The moon passes 0.6° north of Vesta, 5 P.M. EDT

21 Mercury is at greatest eastern elongation (22°), midnight EDT

22 New moon is at 10:46 P.M. EDT

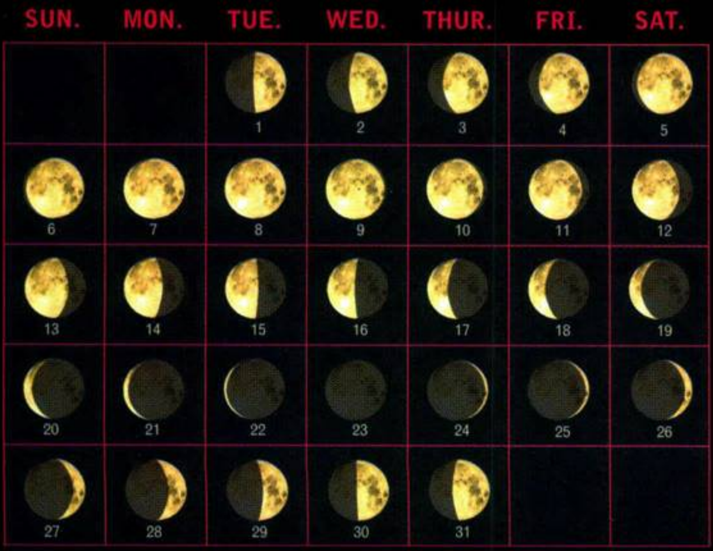
23 Asteroid Eunomia is at opposition, 2 A.M. EDT

24 The moon passes 1.3° south of Jupiter, 3 A.M. EDT
The moon passes 3° south of Mercury, 3 P.M. EDT

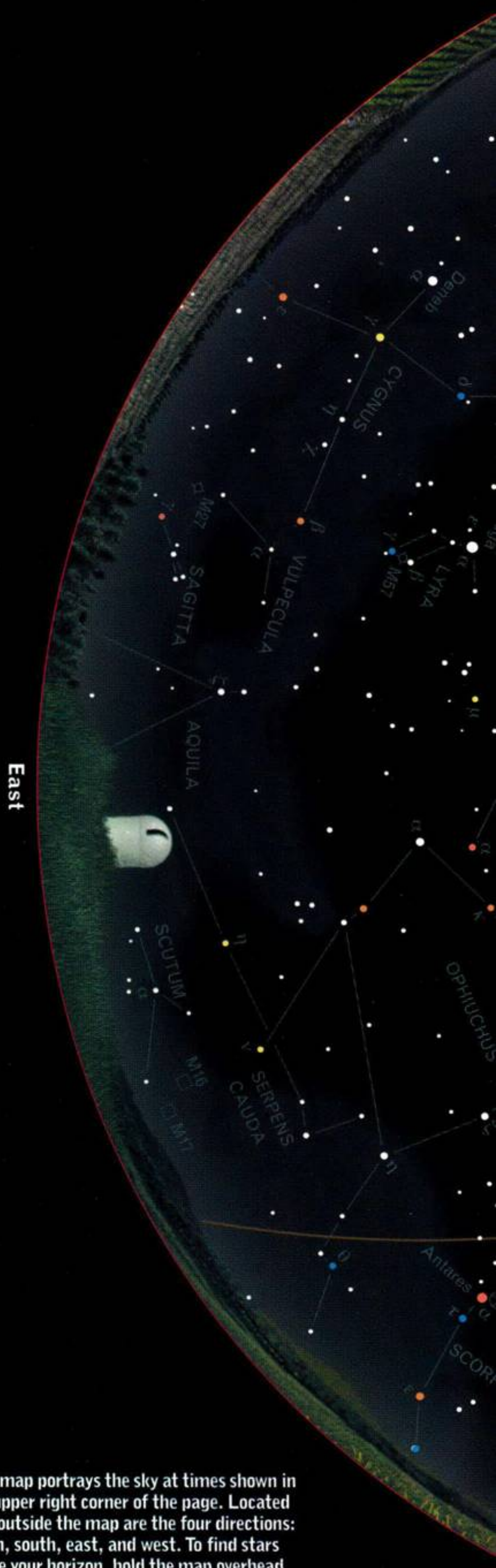
25 Saturn is in conjunction with the sun, 9 A.M. EDT

27 The moon is at perigee (228,685 miles from Earth), 3:02 A.M. EDT
Asteroid Pallas is at opposition, 2 P.M. EDT (page 69)

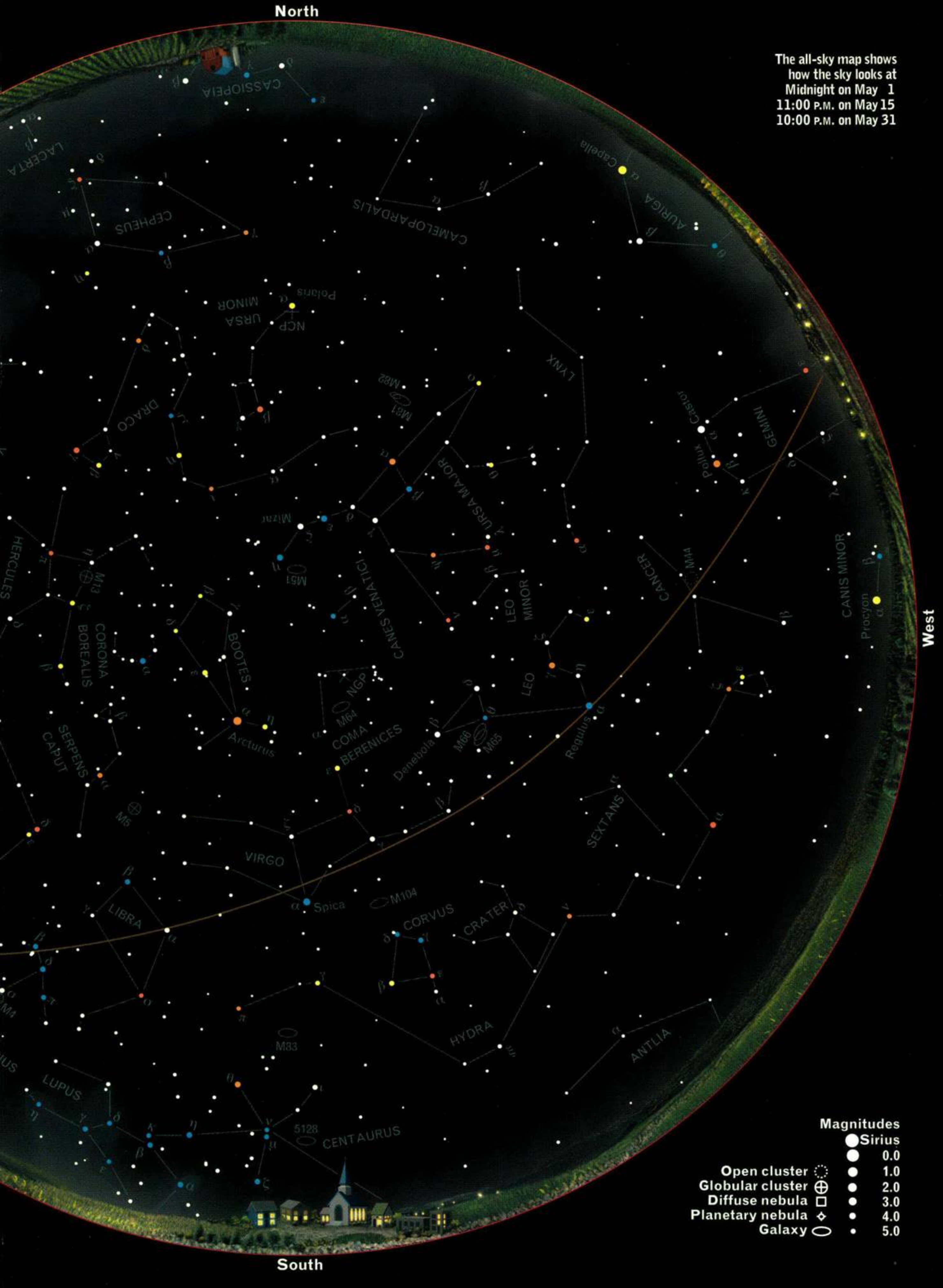
29 First quarter moon is at 6:09 P.M. EDT



SUN.	MON.	TUE.	WED.	THUR.	FRI.	SAT.
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		



This map portrays the sky at times shown in the upper right corner of the page. Located just outside the map are the four directions: north, south, east, and west. To find stars above your horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.


North
CASSIOPEIA
LACERTA
CEPHEUS
CAMELOPARDALIS
Capella
AURIGA
URSA MINOR
Polaris
NCP
DRACO
M82
M81
LYNX
Castor
Pollux
GEMINI
URSA MAJOR
Mizar
M51
CANES VENATICI
HERCULES
M13
CORONA BOREALIS
BOOTES
LEO MINOR
CANCER
M44
CANIS MINOR
Procyon
West
LEO
NGP
M64
COMA BERENICES
Arcturus
Denebola
M66
M65
Regulus
SERPENS CAPUT
M5
SEXTANS
VIRGO
LIBRA
Spica
M104
CORVUS
CRATER
HYDRA
ANTLIA
M83
LUPUS
5128
CENTAURUS
South

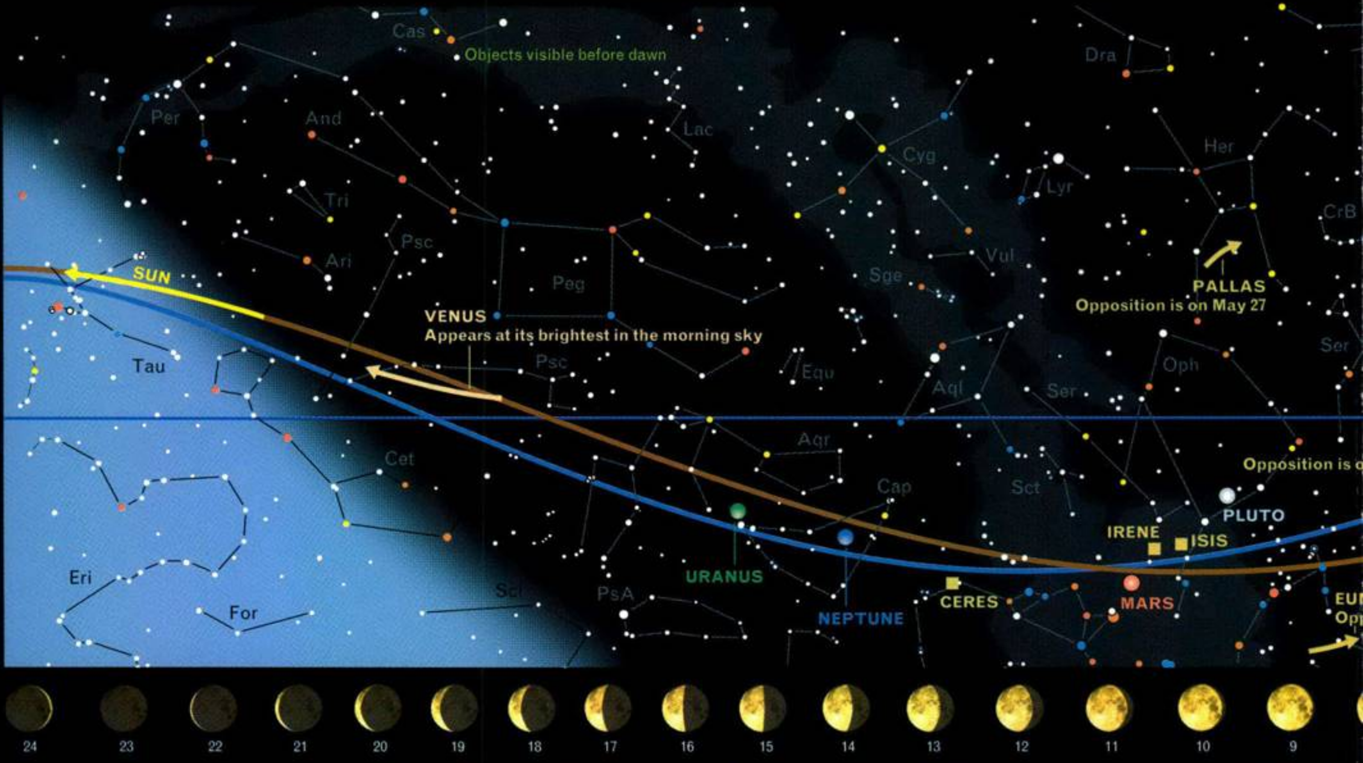
The all-sky map shows
how the sky looks at
Midnight on May 1
11:00 P.M. on May 15
10:00 P.M. on May 31

Magnitudes

● Sirius
● 0.0
Open cluster ◌ ● 1.0
Globular cluster ⊕ ● 2.0
Diffuse nebula □ ● 3.0
Planetary nebula ⟡ ● 4.0
Galaxy ⬭ ● 5.0

Path of the Planets

This map unfolds the entire night sky from evening (at right) until sunrise (at left). Arrows and squares show the movements and locations of solar system objec


Cas
Objects visible before dawn
Dra
Per
And
Lac
Cyg
Lyr
Her
Tri
CrB
Psc
Ari
Vul
Peg
Sge
PALLAS
Opposition is on May 27
SUN
VENUS
Appears at its brightest in the morning sky
Psc
Tau
Equ
Oph
Ser
Aql
Ser
Aqr
Cet
Opposition is
Cap
Sct
PLUTO
IRENE
ISIS
Eri
URANUS
Scl
PsA
CERES
MARS
EU
Op
For
NEPTUNE
24
23
22
21
20
19
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15
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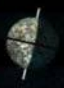
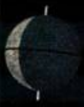
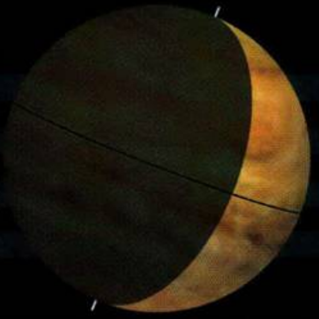
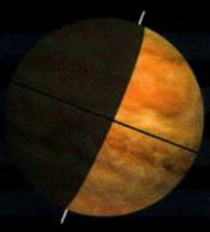
9

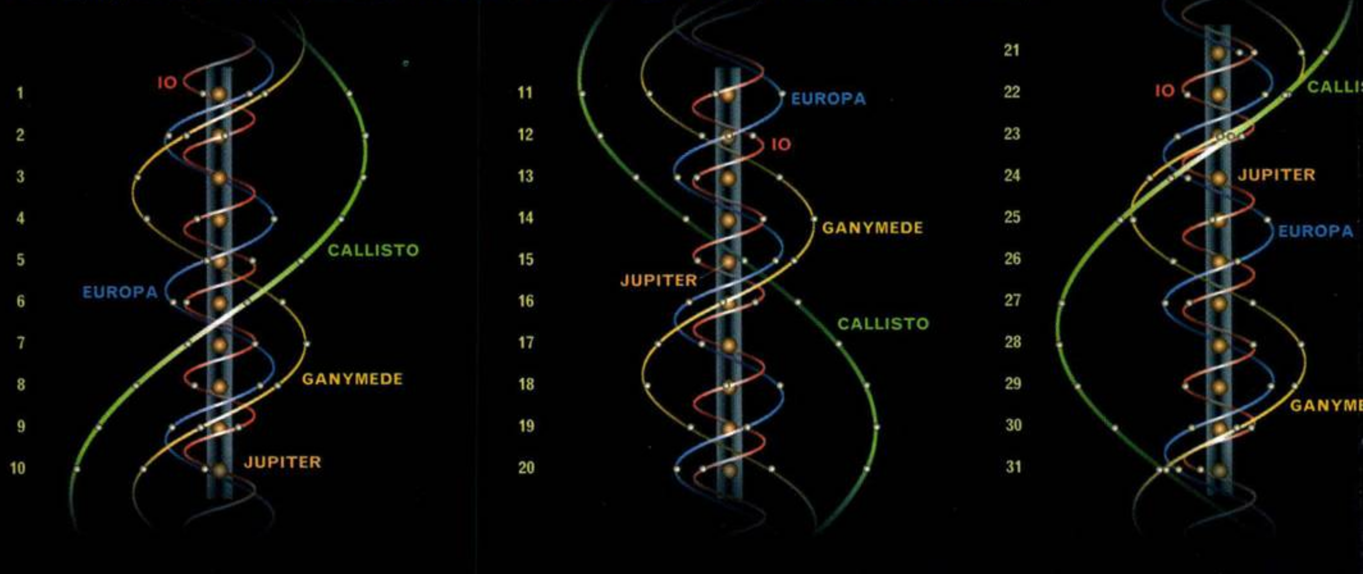
To locate the moon in the sky, draw a line from the phase shown for the day straight up to the curved light-blue line.

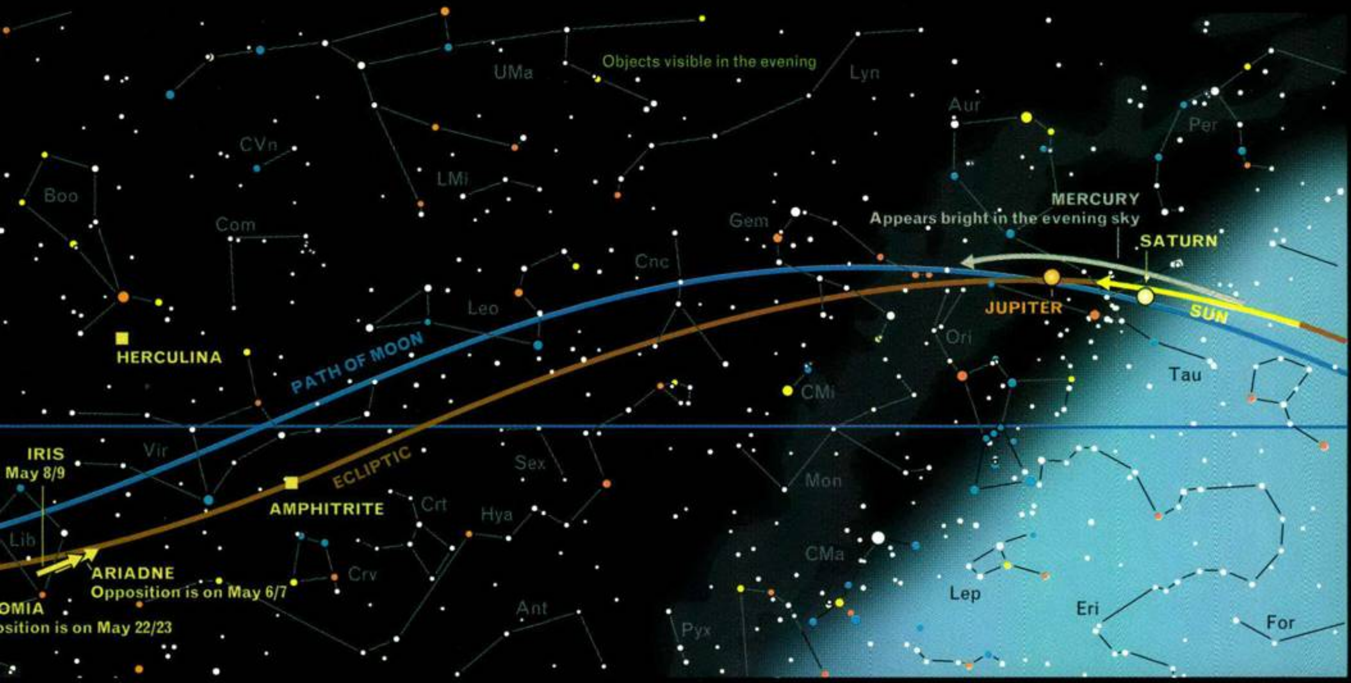
PLANETS	MERCURY	MERCURY	VENUS	VENUS	MARS
Date	May 15	May 31	May 1	May 31	May 1
Magnitude	−0.2	1.6	−4.5	−4.4	−1.1
Angular Size	6.8''	10.0''	40.8''	26.3''	14.3''
Illumination	55%	18%	23%	45%	94%
Distance (AU) from Earth	0.982	0.675	0.409	0.635	0.655
Distance (AU) from Sun	0.360	0.441	0.725	0.728	1.527
Right Ascension (2000.0)	4h52.9m	5h56.8m	0h10.5m	1h32.2m	17h52.8m
Declination (2000.0)	24°57'	24°13'	2°57'	7°27'	−24°09'

Jupiter's Moons

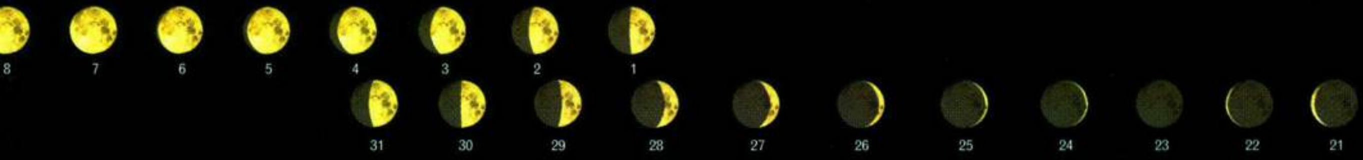
Dots display positions of Galilean satellites at 11 P.M. EDT on date shown. South is at top to match the view in a telescope.



during the month.



Objects visible in the evening
UMa
Lyn
Aur
Per
CVn
Boo
LMi
Com
Gem
MERCURY
Appears bright in the evening sky
SATURN
Cnc
Leo
JUPITER
SUN
HERCULINA
PATH OF MOON
Ori
Tau
CMi
IRIS
May 8/9
Vir
Sex
ECLIPTIC
Mon
AMPHITRITE
Crt
Hya
Lib
ARIADNE
Opposition is on May 6/7
Crv
CMa
Lep
Eri
For
OMIA
osition is on May 22/23
Ant
Pyx



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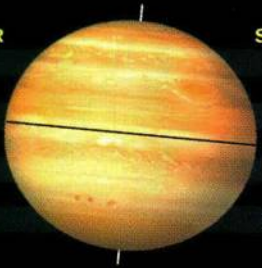
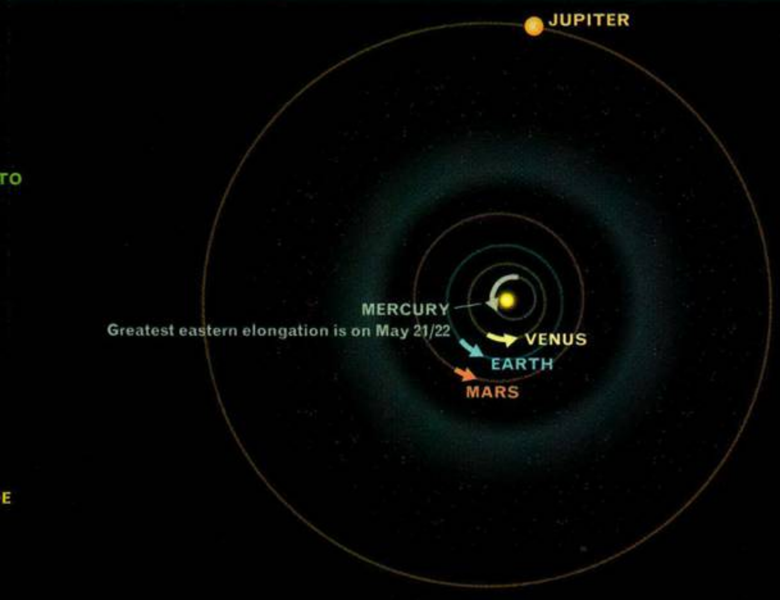


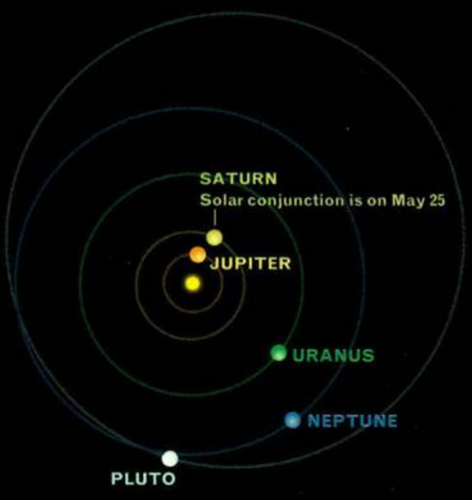
MARS	JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
May 31	May 15	May 1	May 15	May 15	May 15
−2.0	−2.0	0.1	5.8	7.9	13.8
19.1"	32.8"	16.6"	3.5"	2.3"	0.1"
99%	100%	100%	100%	100%	100%
0.489	6.009	10.031	19.953	29.818	29.447
1.488	5.089	9.094	19.969	30.103	30.381
17h45.3m	5h01.7m	3h57.9m	21h49.1m	20h44.6m	16h57.5m
−25°50'	22°23'	18°43'	−13°57'	−17°55'	−11°52'



TO
E
JUPITER
MERCURY
Greatest eastern elongation is on May 21/22
VENUS
EARTH
MARS

The Planets in Their Orbits

Arrows and dots show planets' positions during the month.



SATURN
Solar conjunction is on May 25
JUPITER
URANUS
NEPTUNE
PLUTO

Sanguine Spring Stars

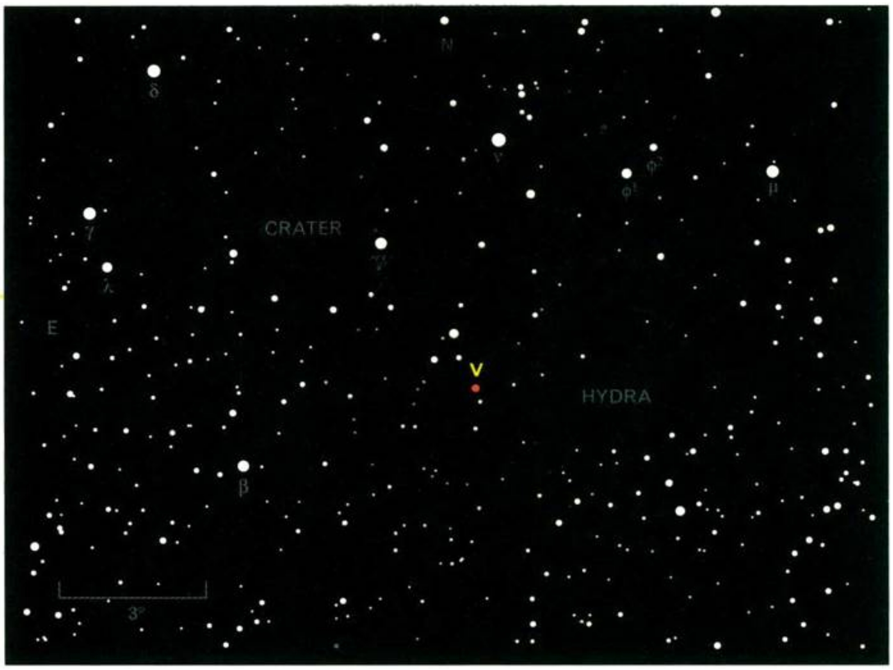
Imagine how special it would be to own a gemstone that changed color unpredictably! You can find some in the vault above, out of arm's reach, but visible in a magnifying glass any time you choose to look up at the starry sky.

We tend to miss those treasures that lie in our celestial backyard when we set our sights on the deep deep-sky. Throughout the year we can garner topaz and ruby stars without making a serious trek into the wilds. From the comfort of our city backyards or rooftops and a modestly sized scope, let's seek out some lovely orange and red gems.

X and T Cancri lie one binocular field to the east (left) of the Beehive star cluster, M44. These two are mostly orange throughout their cycle.

One of the sky's reddest stars is V Hydrae. It's worth the extra effort to star-hop your way south of Regulus to this deep ruby. While you're in the area, skip over to U and V Hydrae. Binoculars are an asset for learning the fainter chain of stars that make up the slithering Hydra. The planetary nebula known as the Ghost of Jupiter (NGC 3242) lies close by.

If V Hya is at the bottom of its brightness curve, you'll need an 8 or 10-inch scope to see its color. SS Virginis hangs around one binocular field to the west of the lovely double star Gamma Virginis. The Big Dipper hosts a pair of jewels too. VY Ursae Majoris is just north of the pointers, while S UMa lies in the same binocular field as Delta UMa, where the Dipper handle meets the bowl. RY Draconis is a bit trickier to find, two binocular fields north of the Dipper's handle.



Bright Red Stars

Star	R.A. (2000.0)	Dec.
X Cnc	8h55.4m	+17°14'
T Cnc	8h56.7m	+19°51'
Y Hya	9h51.0m	-23°01'
U Hya	10h37.5m	-13°23'
VY UMa	10h45.1m	+67°25'
V Hya	10h51.6m	-21°15'
SS Vir	12h25.3m	+0°48'
S UMa	12h43.9m	+61°06'
RY Dra	12h56.4m	+66°00'

Red hot stars are actually cool by stellar standards. The hotter a star, the more it shines towards the blue, higher-energy end of the color spectrum. A blue-white star like Rigel has a surface temperature of about 10,000° C, compared to our sun's 6,000°, and to a red star's 2,000°.

The universe can have a perverse sense of humor — by far the most common stars are the cool red ones, but amateurs hardly see them because they are so faint. We can only detect the closest ones. It turns out that the easiest red stars to find are giant variable stars undergoing pulsations. Many cough up soot that reddens the outgoing starlight.

Here are a few tips to keep in mind when you observe these cool gems. It is very important to use direct vision. All amateur astronomers are brow beaten to use averted vision, glancing to the side, in order to put the object where our vision is most sensitive. However, our best color vision lies at dead center. As noted earlier, a star's color corresponds to its temperature, which varies. The reddest color tends to happen when a variable is faintest, so you'll need to re-visit these lovelies a few times to appreciate the full range of each of their hues. Finally, each person has a different sensitivity to red, and will describe the same shade differently.

The reddish variable star X Cancri lies just southeast of the Beehive Cluster. Len Posner

Keep all of these factors in mind as you head out to hunt red stars, and you may find an entirely new aspect of observational astronomy that is highly enjoyable and addictive.

sky Show

Mars Rules, Assisted by Mercury

A trio of planets congregates in the evening twilight in early May. **Jupiter**, **Saturn** and **Mercury** perform an elegant dance, with Mercury the swiftest, shortly after sunset. Watch the fleeting globe each night at about the same time of the evening and you can spot its relative motion against the other two bright planets.

This is Mercury's best visibility for the entire year. Mercury swings 4° to the right of Saturn on May 5, and 3° to the right of Jupiter on May 14. As it climbs rapidly away from the sun, Mercury glows at magnitude –1.2 as it passes Saturn, which is a whole magnitude fainter. Don't confuse Mercury with Aldebaran, the bright star in Taurus the Bull, that lies to the upper left of Saturn. By the time Mercury passes Jupiter, it has faded to magnitude –0.1. Jupiter remains dazzling at magnitude –1.9. Mercury reaches its farthest elongation east of the sun on May 22 when it has dimmed to magnitude 0.5.

A slender crescent moon stands 4° to the left of Mercury on May 24, making an elegant sight, and Jupiter lies to the lower right of the pair, though it sets quickly. After this point Mercury drops back into the twilight quickly and dims below magnitude 1 on May 26, making it increasingly difficult to spot.

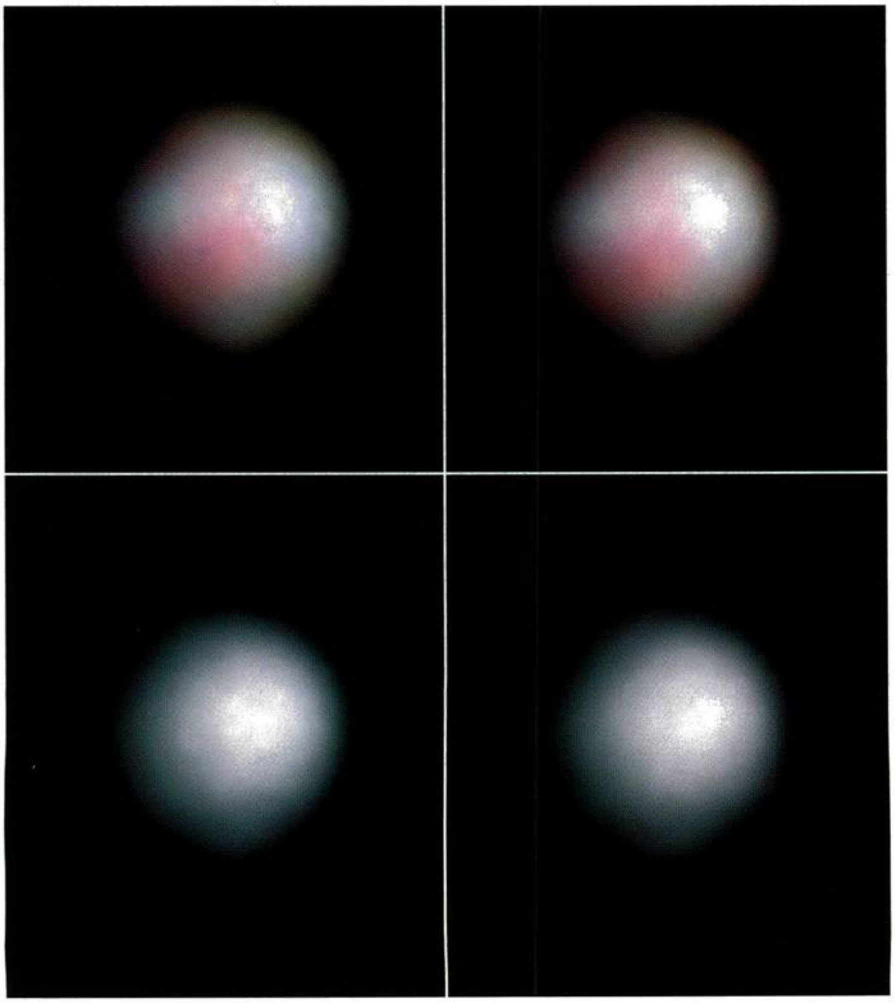
May is the last month of visibility for Jupiter and Saturn in the evening sky this year. By May 8, Saturn sets an hour after the sun, and Jupiter follows an hour later. Both planets are lost in the sun's evening glow by the end of the month. In early May, each planet offers an attractive view in the evening twilight. Jupiter in particular shows plenty of detail during twilight when the contrast between the planet and the background sky is not as harsh as during nighttime. Its brightest (Galilean) moons are also easily tracked during twilight, and this is your last chance to catch some of the eclipses and transits of the moons before Jupiter disappears behind the sun.

Mars is outstanding this month. It rises above the southeastern horizon at midnight at the beginning of May and by 10 P.M. local time on May 31. In addition, the next three months represent the best time in over a decade to view the Red Planet. Earth overtakes Mars during this period, causing Mars to appear to move backward, or "retrograde," against the background stars. Its easterly path from night to night comes to a halt on May 11 just 2° west of the Lagoon Nebula (M8) in Sagittarius the Archer. Mars shines at magnitude –1.4 on this night.

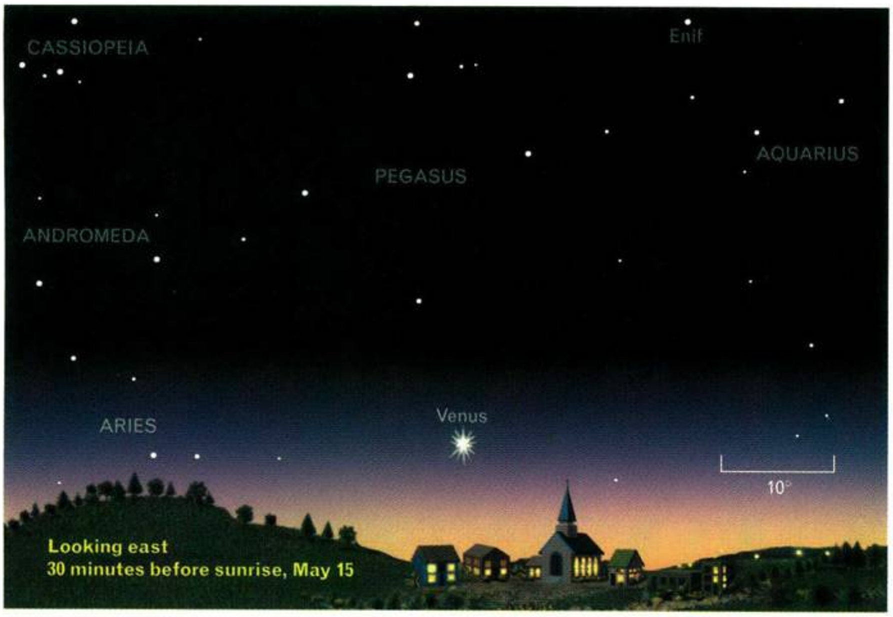
Watch the planet as it brightens by another whole magnitude over the ensuing four weeks, even outshining Jupiter. During the remainder of May, the Red Planet drifts west and crosses back into Scorpius the Scorpion.

Mars presents its best face through a telescope. The apparent diameter of Mars grows from 14" to 19" during the month as its distance from the Earth shrinks from 60 million miles to 45 million miles. By May 31, it shines at a brilliant magnitude –2.0 and dominates the southern sky by late evening. Its brilliant orange color beckons the observer to take a closer look.

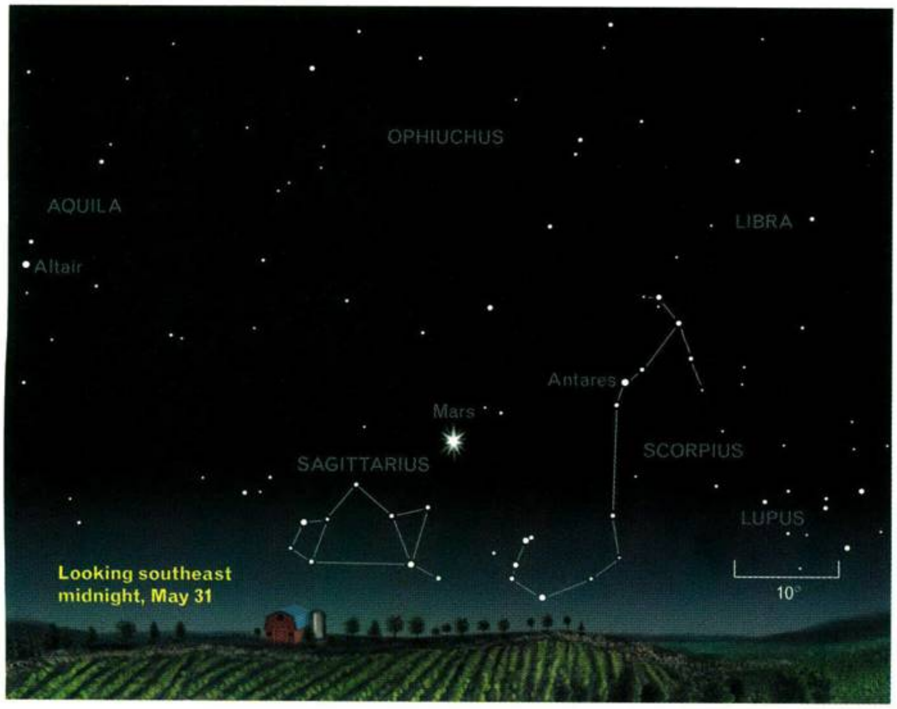
The first-time viewer of Mars will likely be disappointed: The shimmering orange disk seems to show no detail. Don't be put off by first impressions; Mars is challenging you. You need to observe Mars at the best possible times. Wait for moments of great seeing, when the atmosphere is momentarily motionless, and dramatic detail is visible. Visual telescopic



Approaching opposition, the Red Planet stands out in red light (top) and green and blue light on December 28, 2000. Don Parker



Looking east
30 minutes before sunrise, May 15



Looking southeast
midnight, May 31

observing of Mars can pick out subtle details on the planet that are often lost in photographs.

To draw Mars, use a disk of 42mm diameter. With Mars's diameter of 4,200 miles, this disk produces a scale of 1mm per 100 miles. Carefully draw the principal features that you see. Because Mars rotates in a little more than 24 hours, each night it shows us almost the same hemisphere. In 24 hours it rotates 351° in longitude, making the planet appear to back up 9° on consecutive nights. This means that any given feature, such as the dark and prominent Syrtis Major, is on view for almost 10 days during a 36-day period. Get to know the planet's features by observing them regularly before you begin sketching, and you'll produce portraits that will make you proud.

To improve your chances of viewing the subtle features, try using color filters. A Wratten #25 red filter will enhance the surface features, while a Wratten #80A blue brightens the cloud features that tend to hug the morning terminator of Mars. Don't be disappointed on your first try: Details visible using color filters become easier to see with practice night after night.

While Mars is so bright it is hard to miss, at the opposite end of the scale is **Pluto**, visible at the same time that Mars is on view. Pluto is always a challenging object, since it hovers at magnitude 13.7 at opposition. It lies about 2° southeast of the star 20 Ophiuchi in a crowded starfield.

To track down Pluto, you'll need at least an 8-inch scope. Expect to spend some time identifying the correct star field using low magnification; once you have the correct field of view located, move to a higher magnification. This effectively darkens the background sky and will assist in detecting the ninth planet in the solar system. Draw the star field that you see for a few nights, and identify the "star" that moves — you will have captured Pluto. Alternatively, if you have a CCD camera, image the star field over a few nights and make a small time-lapse movie showing Pluto's motion. Pluto reaches opposition on June 4.

Venus has moved into a prominent position in the predawn sky among the stars of Pisces the Fish. It rises in the east an hour and a half before the sun and shines at magnitude –4.5. As it moves away from the sun, the telescopic appearance of Venus reveals a waxing crescent, reaching an almost half-illuminated globe by the end of May. But no sooner does Venus reach a decent altitude than the glow of twilight appears, marking the end of another night of planetary observing. Although Venus shows little detail in a telescope due to its thick blanket of opaque clouds, simply seeing the brilliant sister planet of Earth brings a warm feeling on cool mornings.

Meteors and Moons

Tracking down Albategnius

One of the oldest features on the moon is the 80-mile diameter walled-plain Albategnius, named after an Arabian astronomer who lived from 850-929 AD. It stands in a part of the lunar highlands close to the two well-known features, Ptolemaeus and Hipparchus, and is best seen at first quarter.

The relative age of Albategnius is revealed by the significant secondary cratering that breaks its walls. Most conspicuous is the younger 26-mile crater, Klein, that has dramatically altered the southwestern side of Albategnius. A smaller crater is superimposed on Klein, breaking its northeastern wall and indicating the smaller crater is younger still – part of the unfolding history of the moon that is forever frozen into its surface for us to decode.

The floor of Albategnius has been flooded with a mare-type lava that has partially buried the giant central mountain peak. This mountain rises almost 14,000 feet above the lava plain below. Under special conditions of low angle illumination around times of sunrise and sunset on Albategnius, several ridges and two circular depressions, similar to those found on Ptolemaeus, might be spotted on the crater floor. The precise timing of the correct illumination may not occur every month for a particular geographical location. However, watch sunset on Albategnius during the waning last quarter moon in the early morning of May 15.

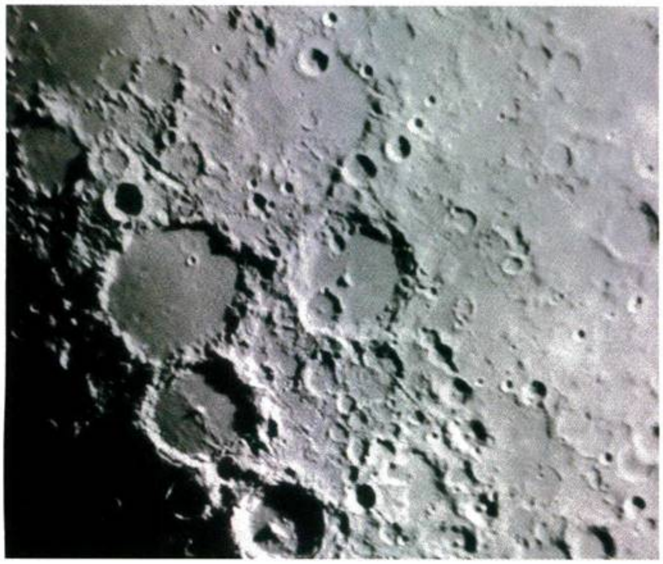
The Eta Aquarid meteor shower is severely affected by the near full moon, and although no other showers provide any significant observable activity, keep a look out for the occasional sporadic meteor. Typically this background rate of meteors averages seven per hour.

Jovian Satellite Events

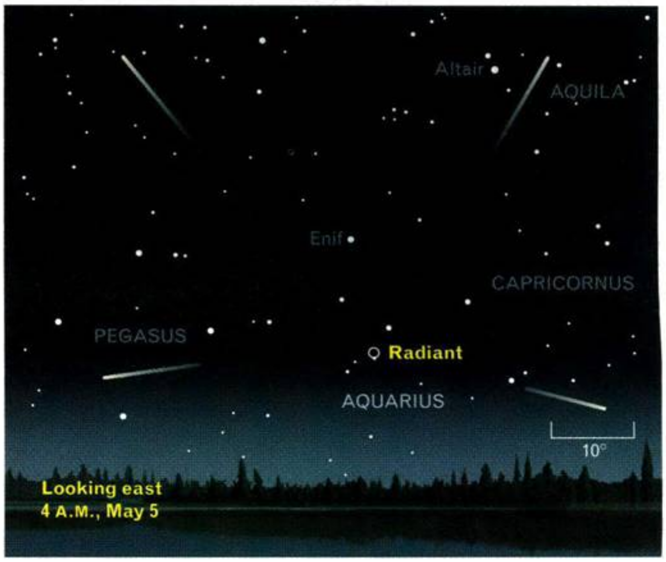
May 2	22:50	I.Tr.I.
	4:32	I.Sh.I.
May 3	20:03	I.Oc.D.
	22:55	I.Ec.R.
	23:17	II.Oc.D.
May 4	19:34	I.Tr.E.
	20:14	I.Sh.E.
May 5	19:04	II.Sh.I.
	20:26	II.Tr.E.
	21:43	II.Sh.E.
May 9	20:19	III.Sh.E.
May 10	22:04	I.Oc.D.
May 11	19:23	I.Tr.I.
	19:56	I.Sh.I.
	21:36	I.Tr.E.
	22:09	I.Sh.E.
May 12	19:19	I.Ec.R.
	20:35	II.Tr.I.
	21:39	II.Sh.I.
	23:15	II.Tr.E.
May 14	19:19	II.Ec.R.
May 16	19:55	III.Tr.I.
	21:52	III.Sh.I.
	23:26	III.Tr.E.
May 18	21:25	I.Tr.I.
	21:52	I.Sh.I.
May 19	21:14	I.Ec.R.
	23:23	II.Tr.I.
May 21	21:57	II.Ec.R.
May 27	20:10	I.Tr.E.
	20:28	I.Sh.E.
May 28	21:18	II.Oc.D.

Jovian Moon Events for May 2001

Times are Central Daylight Time, and are accurate to within one minute. Io = I, Europa = II, Ganymede = III. No Callisto events occur. Oc = occultation; Ec = eclipse; Sh = shadow; Tr = transit; D = disappearance; R = reappearance; I = ingress; E = Egress. For some events the sun will still be in the sky for western U.S. observers, but will have set for east coast (U.S.) observers. In addition, Jupiter will set earlier for east coast observers.



The lunar crater Albategnius (center) is a walled plain spanning 80 miles. Jack Metcalfe

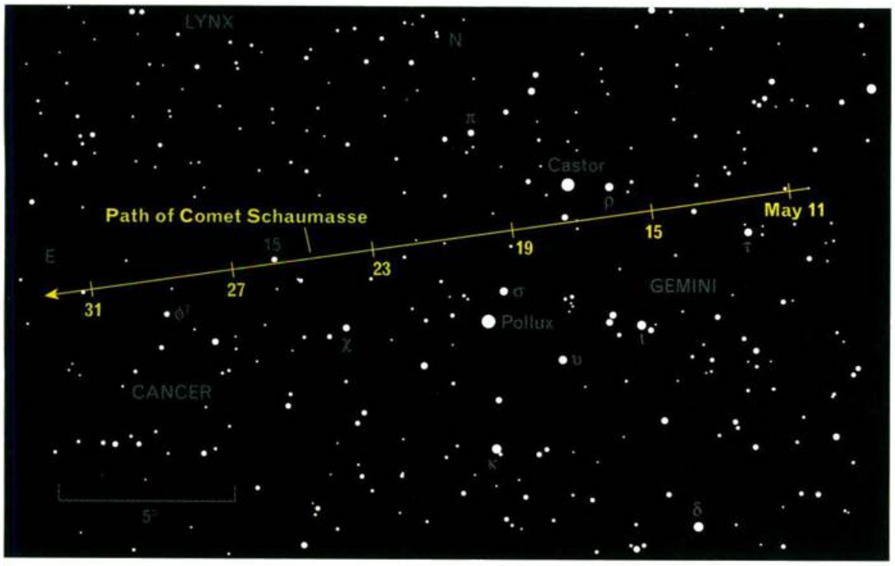


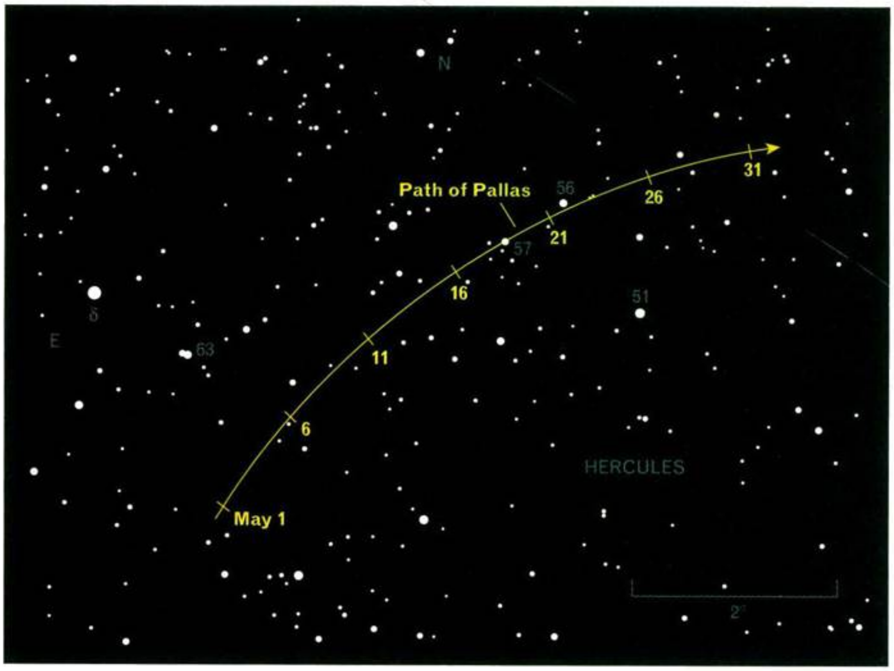
Comet Schaumasse Splits the Twins

It's about time that we have a nicely placed comet gracing our evening skies. Comet 24P/Schaumasse silently sails upward against the setting winter constellations, as if valiantly trying to escape the sun's pull. At about 11th magnitude, this fuzzy snowball should be a reasonable catch with a small telescope under a dark sky.

W. A. Schaumasse first set eyes on this comet in 1911. It orbits the sun every 8.25 years and never gets closer to the sun than Earth. Only once every three or four revolutions can amateurs get a good look at it. Schaumasse needs to be as near to the sun as possible (it reaches perihelion on May 2), and Earth has to be close by. We're not perfectly aligned this time around, but while we wait for the "big one," we may as well enjoy the show.

Wait until the moon is out of the evening sky, after mid-month, and head out into the country to escape the city lights, which throw an obscuring veil into the sky. Make sure you find a spot to the west of any big city. Comets are unusual beasts, so remember to use a wide range of magnifications. At 50x, sweep for a faint tail that points away from the sun. On the night of the 18th, Schaumasse lies right between Castor and Pollux. Castor, the one closer to the bright star Capella, is a lovely double star for small scopes. Check it out.





Pallas Collars Hercules

The solar system is always on the move. When seeking asteroids, use the starry background as your reference marks. Most of the time the stars are of similar brightness, so you have to be careful, but sometimes they reveal their identity easily because they're close to a bright star and move quickly. It can be harder to notice Jupiter and Saturn shift because their bright glare hides the background stars from view.

Movement is what betrayed Pallas back on March 28, 1802, to Heinrich W. Olbers. Use the chart to zero in on Pallas's position in Hercules, then make a quick sketch of the field. Come back a night or two later to find the one that moved. Pallas will still be in the same low power field 24 hours later, about 15' northwest (about half the moon's apparent diameter).

If you want to watch it move during one evening, look for Pallas only 5' northwest of 57 Herculis on the 19th, and 4' south of 56 Herculis on the 22nd. Opposition is an important time for outer solar system objects, because they reach their peak brightness when they lie opposite the sun. Pallas will hit magnitude 9.2 at opposition on May 27th.

Still going strong after its April 21 opposition, asteroid 532 Herculina is about as bright as it can get, at 9th magnitude. On the nights of the 17th through the 19th, it lies only 15' south of the star 14 Bootis. A

Martin Ratcliffe is Director of Theaters at the Exploration Place in Wichita, Kansas. Alister Ling is a meteorologist working for Environment Canada in Alberta.

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hello DARKNESS my old friend

Clear skies should reign over southern Africa for the third millennium's inaugural solar eclipse.

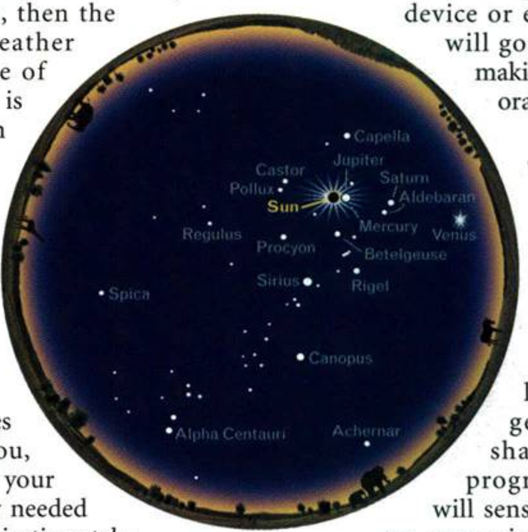
by Richard Talcott

Racing across Earth's surface at more than 1,000 miles-per-hour, the moon's shadow seems eager to cast its magical spell. An almost palpable sense of wonder grips the waiting throngs as totality approaches. Then, as the last glimmer of sunlight disappears behind the moon's limb, day turns to night and the eerie sounds of silence descend upon the land.

Thanks to a remarkable coincidence that renders the moon almost exactly the same size as the sun in our sky, this majestic display lasts just a few fleeting moments. But it impresses so much that nearly everyone who has witnessed a total solar eclipse vows to see another.

Well, the opportunity has arrived: On the afternoon of June 21, the longest total eclipse in nine years traverses southern Africa. The path of totality cuts a narrow swath across Angola,

Majestic coronal streamers should greet eclipse chasers in southern Africa. Christian Viladrich



Zambia, Zimbabwe, Mozambique, and the island nation of Madagascar. As many as 4½ minutes of totality await those on the center line along the Angolan coast, a number that dwindles to 3 minutes in coastal Mozambique and about 2½ minutes in Madagascar.

If the generous length of totality doesn't impress you, then the chance for clear weather should. At this time of year, southern Africa is well into its dry season and clear, sunny skies are the rule. The cool, dry weather also keeps mosquitoes at bay — a distinct bonus in a land where insects can carry unpleasant pathogens.

Such unpleasantries shouldn't frighten you, however. Check with your doctor to line up any needed shots — some immunizations take weeks before they become effective. Then, as you're getting ready to pack, be sure to throw in a good insect repellent.

Once you're in Africa and the big day is at hand, reach your viewing site a couple hours before the eclipse begins. That leaves plenty of time to set up before the show starts. During the partial phases, eye safety is paramount: Sunlight can quickly and painlessly damage the eye's retina. For a direct view of the sun, use only Mylar filters, metal-on-glass filters, or #14 arc-welder's glass.

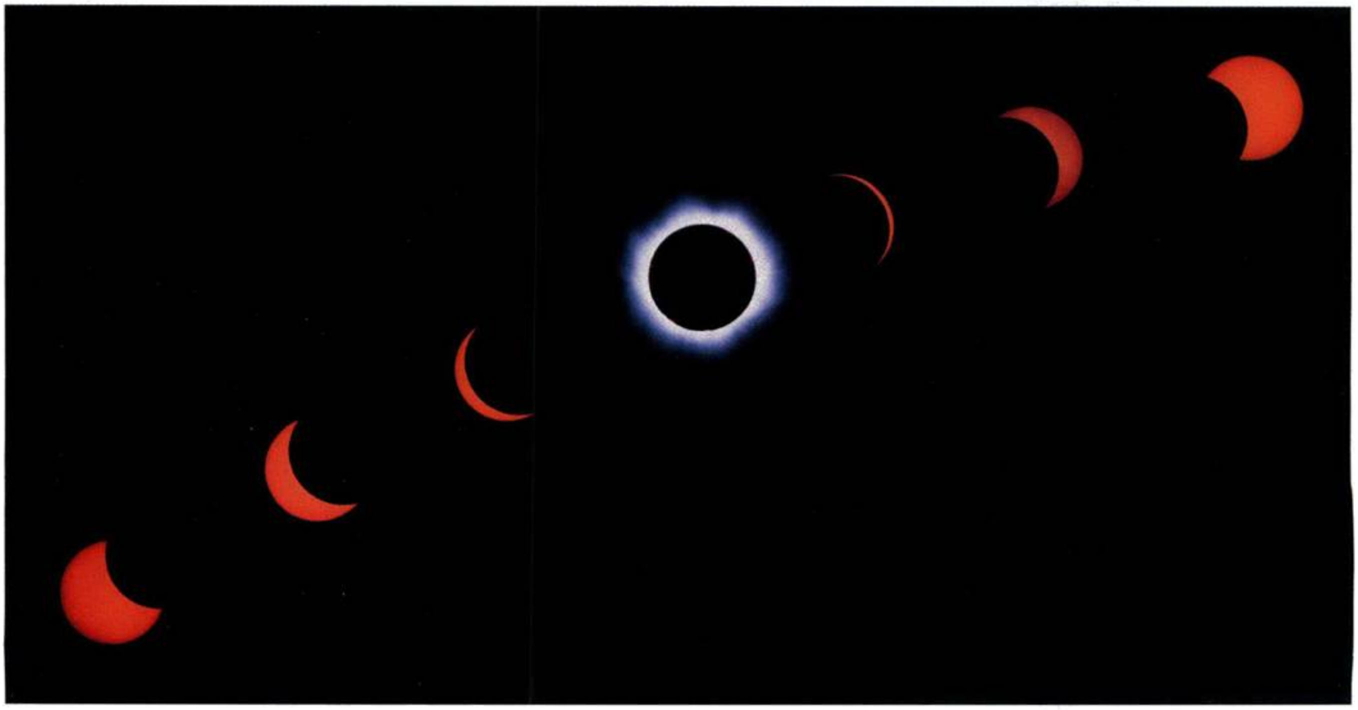
You can also view the partial phases indirectly by projecting the sun's image. Take two pieces of cardboard and punch a tiny hole in one of them. Then let the sun's light pass through the pinhole onto the second piece of cardboard. Local citizens may want to watch the eclipse too; a projection device or extra filter material will go a long way toward making their day a memorable one as well.

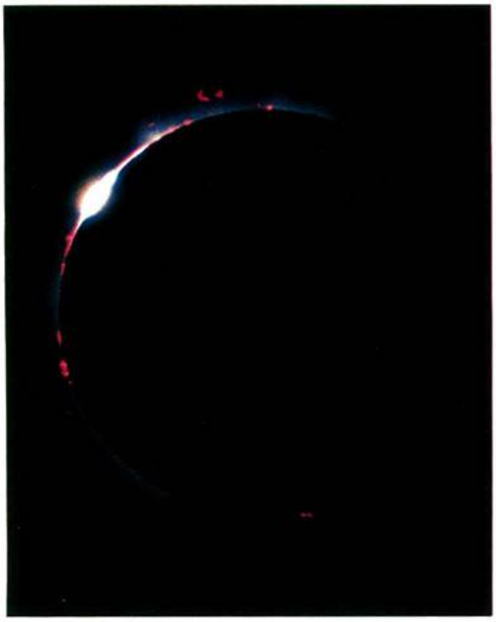
Once the moon covers more than half the sun, watch for subtle changes. Look for solar crescents under trees and bushes, images projected by the tiny gaps between leaves. Shadows in general will appear sharper as the eclipse progresses. And wildlife will sense something's going on, preparing for nightfall even though it's the middle of the day.

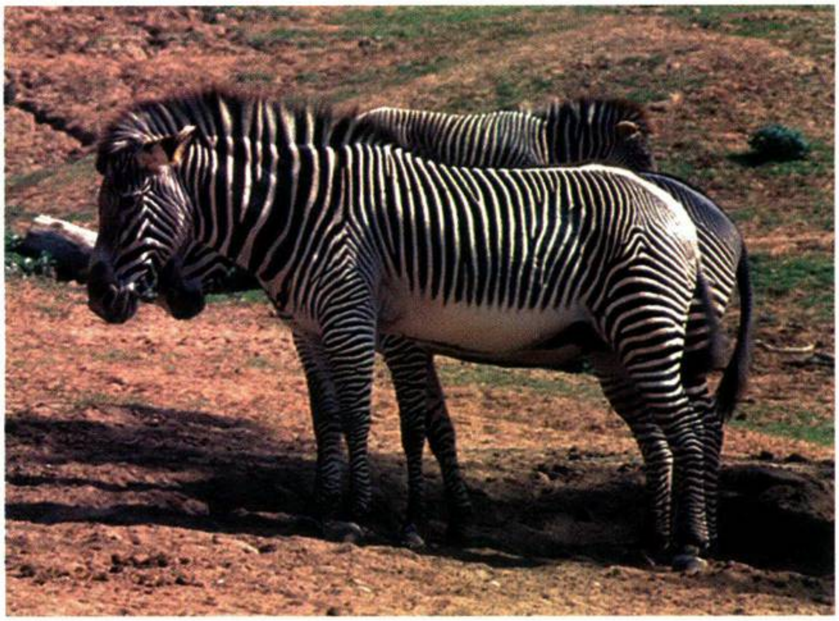
In the last minute before totality, the solar crescent breaks up as lunar mountains poke through it. Known as Baily's beads, this string of pearls shrinks as the moon continues its relentless march. Finally, just a single bead remains — the glorious diamond ring.

When the advancing moon extinguishes the diamond ring, totality has arrived. Remove the solar filters and examine the eclipsed sun with your eye, binoculars, or a telescope. After your eyes adjust to the

Expect Jupiter, Saturn, and Sirius to appear conspicuous once the sun disappears (above). Totality marks the brief but glorious midpoint of the entire eclipse (below). Rémy Courseaux







The last glints of sunlight passing through lunar valleys are known as Baily's beads (left). Be sure to watch for the reactions of the big African animals as darkness comes at midday (right).

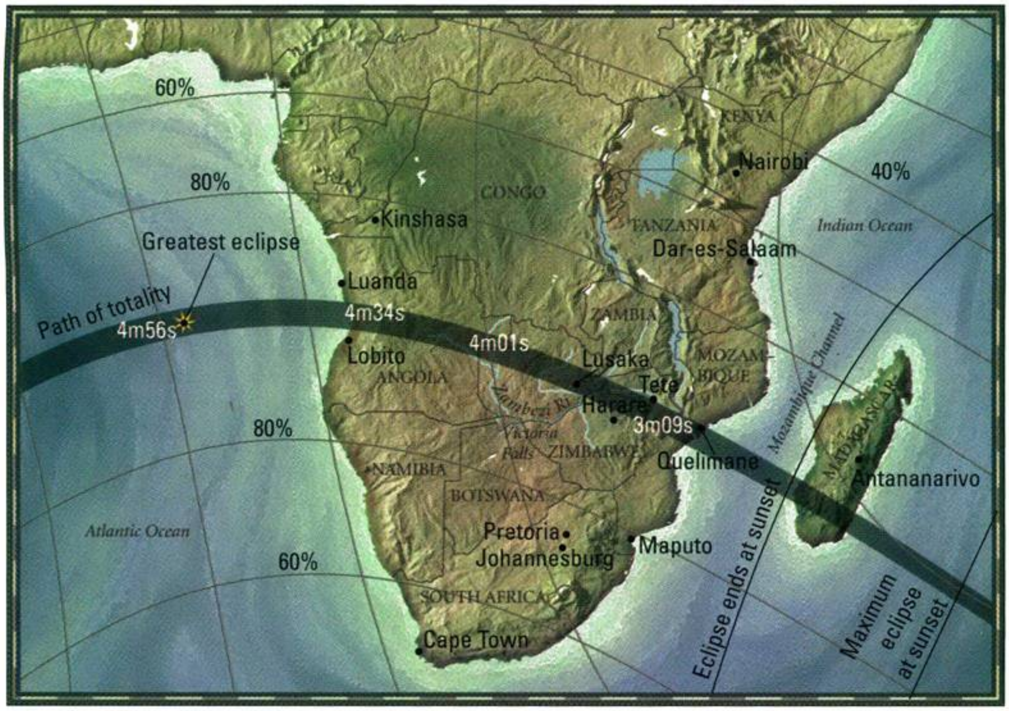
Left: Hal Jandorf; right: © 2000 www.arttoday.com

sudden darkness, the corona blazes into full view. The gauzy, pearly-white corona, the sun's outer atmosphere, typically stretches a few times the sun's diameter. Watch for delicate loops, swirls, and streamers in the corona. Also look for fiery red prominences, features that lie close to the sun's surface and will appear just above the moon's outline.

Also take the time to observe your surroundings. Notice the color of the sky and the twilight hues that ring the horizon. You should see the brightest planets and stars during totality. Most prominent will be Jupiter, located 5° west of the sun. Saturn, Sirius, and Canopus should also be conspicuous. Although Venus shines brightest of all, it lies near the horizon as seen from western Africa and sets before totality begins in spots east of central Zambia.

Totality ends when a second diamond ring appears on the moon's opposite side. That's the signal to replace all solar filters. Although the sequence of partial phases now plays out in reverse, most people pay scant attention — they've seen the show they came for. It's time to relax and contemplate the next total eclipse, 18 months from now in southern Africa and Australia. **A**

Richard Talcott is a senior editor at Astronomy.


60%
80%
Greatest eclipse
Path of totality
4m56s
Kinshasa
CONGO
Luanda
4m34s
Lobito
ANGOLA
4m01s
KENYA
Nairobi
40%
Indian Ocean
TANZANIA
Dar-es-Salaam
ZAMBIA
Lusaka
Tete
MOZAMBIQUE
Zambezi R.
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Victoria Falls
ZIMBABWE
3m09s
Quelimane
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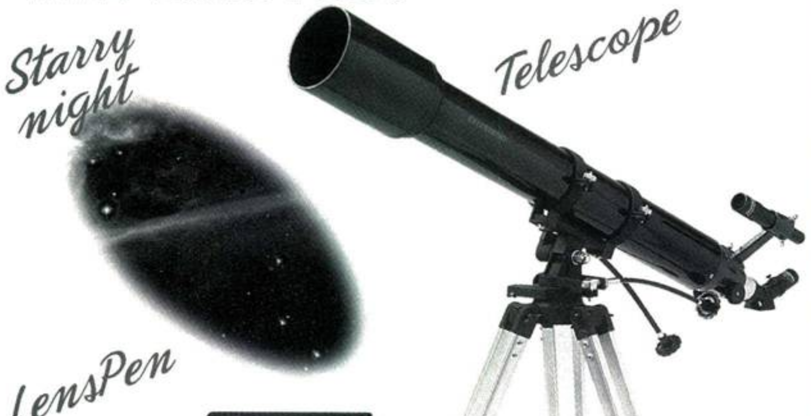

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Mention Ad A-7

HOLDING STEADY

A rock-stable telescope mount enables hours of successful stargazing.

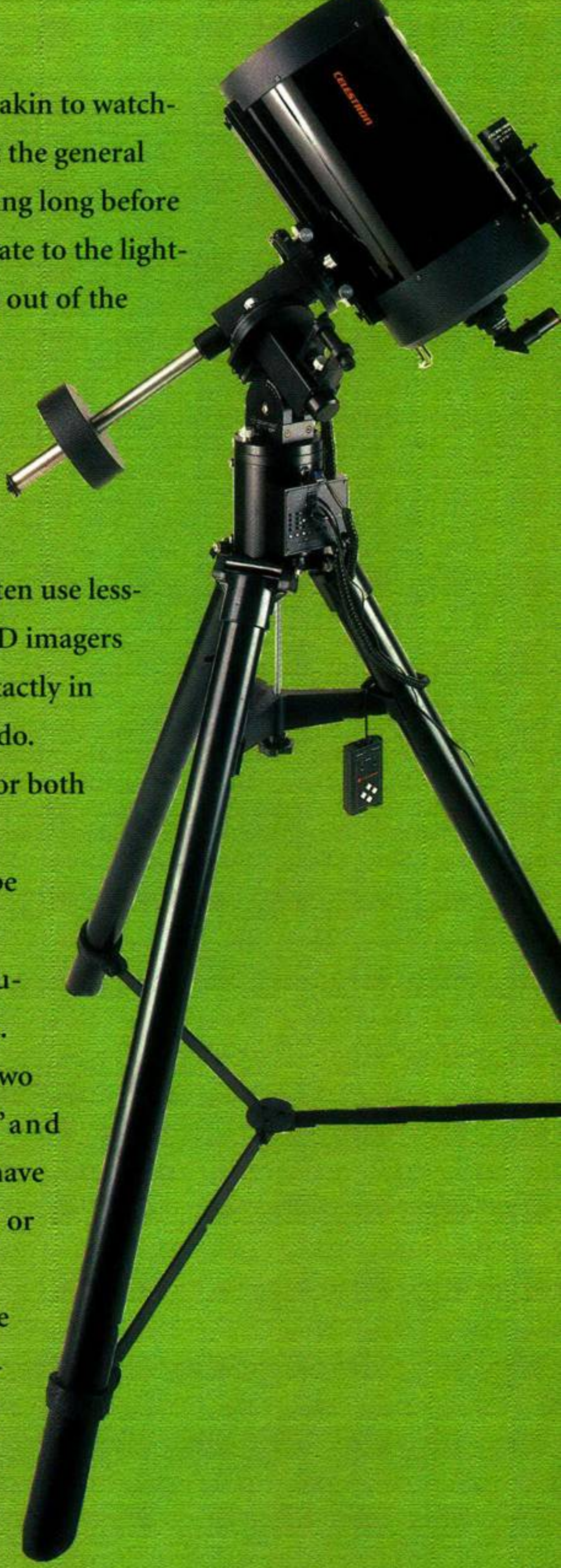
by Steve Edberg

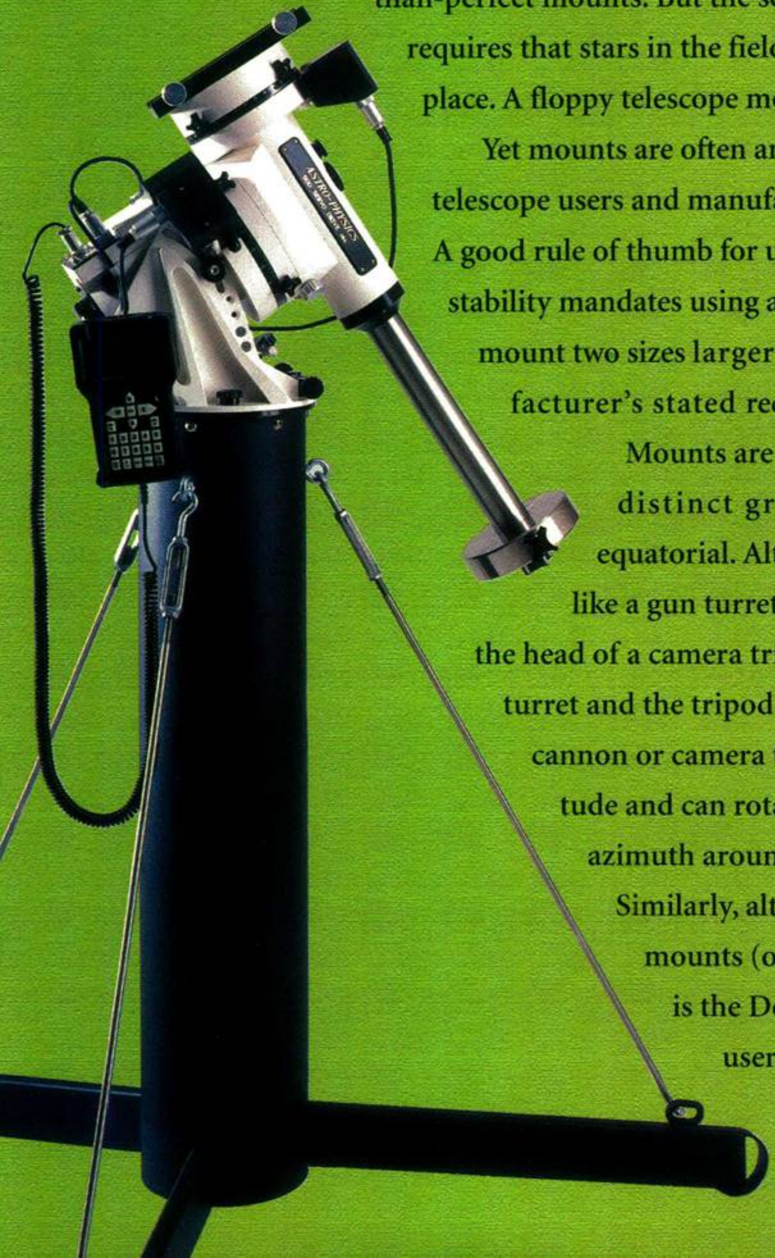
Observing the stars with a rickety telescope mount is akin to watching TV with a flickering vertical hold: While you'll get the general idea of what's going on, chances are you'll stop watching long before the show is over. Likewise, mounts that sway and vibrate to the lightest touch or breeze send their images reeling about or out of the field of view. Enhance your viewing pleasure by using a steady mount with your telescope.

The advent of CCD cameras and guiders brings the problem of telescope stability to the forefront. Visual observers can make continual adjustments, and even photographers guiding long exposures often use less-than-perfect mounts. But the sensitivity of CCD imagers requires that stars in the field of view stay exactly in place. A floppy telescope mount just won't do.

Yet mounts are often an afterthought for both telescope users and manufacturers. A good rule of thumb for ultimate telescope stability mandates using an equatorial mount two sizes larger than the manufacturer's stated recommendations.

Mounts are classified into two distinct groups: "alt-az" and equatorial. Alt-az mounts behave like a gun turret on a battleship or the head of a camera tripod. Both the turret and the tripod head elevate the cannon or camera to a desired altitude and can rotate to a desired azimuth around the horizon. Similarly, alt-az telescope mounts (one major style is the Dobsonian) permit users to aim their





Previous page: A solid central column on the Astro-Physics mount (left) ensures its sturdiness, while Celestron's heavy tripod (right) supports an equatorial head, electronics pier, and counterweight. *Astronomy:* Jim Forbes

telescopes anywhere in the sky. Because of their size, stability is relatively easy to achieve.

During observing sessions, Earth's rotation shifts the field of view. An observer (or a computer) must constantly adjust the telescope's position in both altitude and azimuth. Because these change at different rates, tracking an object across the sky over the course of a night requires two motions. These motions also depend on the object's position in the sky relative to an observer's geographic position.

An equatorial mount simplifies this two-motion problem, but its complicated setup takes a bit of time. Whereas an alt-az mount is ready for use when placed anywhere with a clear view of the sky, a user must orient his or her equatorial mount properly. The principal axis, called the Right Ascension (R.A.) axis, should precisely parallel Earth's rotation axis. Once aligned, only one clock-driven motion is necessary to track objects across the sky. Another axis, the declination (Dec.) axis, runs perpendicular to the R.A. axis. These two axes allow the telescope to swivel to the desired orientation. With the clock motor on, the telescope follows the desired object as Earth rotates.

The most common equatorial mounts include the fork and the German equatorial varieties. A fork mount has one or two arms (tines) that orient the telescope parallel to the R.A. axis. German equatorial mounts appear ungainly because their axes and counterweights meet the telescope at a strange angle with respect to gravity — making the whole setup look like a pair of crossed Ts.

Some manufacturers cater to observers who want stable mounts with precision tracking capability. These advanced electronics aid viewing — so much so that they can be compared to the help provided by assistants to astronomers observing from large, professional observatories. Three models that stand out are discussed here.

Ease of Assembly

All the parts of the Astro-Physics 900 GTO mount slip together easily. This German equatorial mount features some interesting design and construction characteristics. The head (the support for the moving portions of the mount) is on a central pedestal — or pier — with legs at the bottom.

I was surprised at the ease of assembly. While that in itself doesn't ensure stability, hand-tightening the tension rods between the legs and top of the stand results in a surprisingly sturdy stand. I attached the equatorial head and its components with thumbscrews. The only time I needed tools (Allen wrenches) was to fasten the telescope mounting plate.

The next step is orienting and aligning the assembled mount so that the R.A. axis parallels Earth's axis. Here a user might be puzzled by the lack of apparent adjustments.

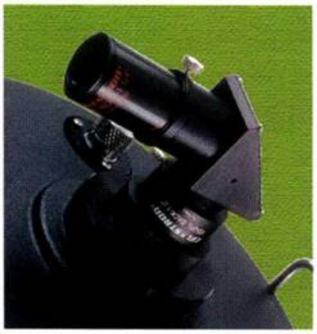
Contrary to popular opinion, a telescope mount does not need to be level, though that is helpful during critical alignment. The Astro-Physics mount cannot be conveniently leveled. Blocks set under the (non-adjustable) footpads make the pier vertical. In order to fine-tune the alignment, I looked through a hole in the R.A. shaft and used a hand screw to adjust altitude; azimuth is adjusted with opposing, pushing thumbscrews. Use the drift method for exact alignment. Watch stars as the telescope tracks and then adjust the pointing (in altitude and azimuth) of the R.A. axis to minimize — and then zero-out — the drift.

Follow the explicit instructions for setting up and using the mount. The power supply that turns the R.A. and Dec. axes uses 12 volts direct current (VDC). Believe it. The electronic hand control won't work properly using 12 VDC connected to a transformer plugged into a wall. Plan on using a 12-volt battery with the mount both at home and at remote observing sites.

The clock drive is so quiet that you might not think it's running unless you're looking through the eyepiece. As soon as power is applied, the mount tracks and can be pointed with its R.A. and Dec. motors. Again — follow those instructions. But the large, heavy hand control offers much more, including "Go To" capability once it has been initialized for the night. Be warned — getting the "Go To" to work consistently requires some effort.

The 900 GTO mount is also designed to work with the Astro-Physics DigitalSky Voice software.

Left, clockwise from bottom: A Celestron finderscope helps point the way; the eyepiece comes into play after the CI-700 is set up for use; the CI-700's easy-to-install cables connect the electronics pier to the hand control and motor drive, which operates at varying speeds. Below: Three sets of gradations etched into the CI-700's equatorial head guide users. *Astronomy:* Jim Forbes



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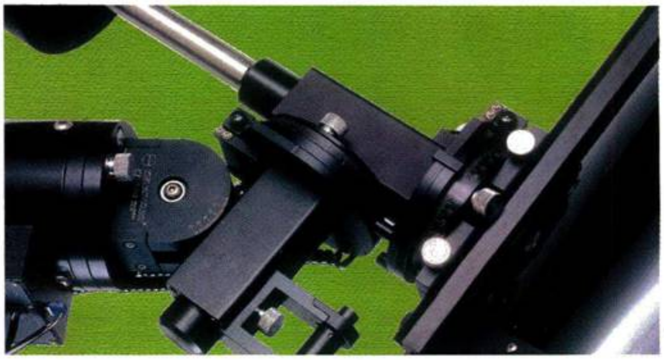

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Large Diameter Legs

Celestron uses a different approach in building a sturdy telescope mount. Its CI-700 uses three long, large-diameter legs, sprouting from below the head. These come in a single assembly, though you must remove the plastic spreader from the threaded rod and reposition it during setup. A second spreader near the bottom of the legs remains slack even when the upper spreader is engaged tightly. Finally, a coupler that holds the electronics box is Allen-bolted to the top of the tripod and to the mount head.

Celestron suggests another tack for achieving polar alignment. (You might need to use blocks under the tripod legs.) Bolt the separate pole-finder telescope to the rear of the equatorial head. While you will probably have to roll the telescope mounting plate and telescope to one side to permit a clear field of view, you can now use the pole-finder, with its Polaris pointing reticle, for a quick, reasonably accurate polar alignment. Drift aligning (follow the supplied directions) is still necessary for the most demanding applications. And, since the pole-finder may arrive loose in its mount, drift aligning may also be necessary the first time it's used. Directions explain how to use the pole-finder. You will have to reverse these to align it initially. Adjust the azimuth and altitude using the Allen bolts.

The dual-T design limits the range of motion of all German equatorial mounts. Sooner or later, the mounting plate, counterweight, or telescope collides with the mount. The CI-700 is designed for use between latitudes from 13° to 65° north or south of the equator. Once the counterweight is added, that range is reduced to 20° to 65°.

Another limitation appears when observing the most important area of the sky — along the meridian. The meridian is an imaginary circle that goes through the celestial poles and the observer's zenith — the place in the sky where an object reaches its maximum height during its nightly passage.

German equatorial mounts require a 180° change in position in order to avoid a collision between moving and stationary parts. The CI-700 seems particularly limited in its freedom to cross the meridian before the 180° flip. (A major advantage of fork mounts is that they permit tracking from horizon to horizon with no flip.)

With most alt-az mounts, only one axis requires balancing. Not so with equatorial mounts. With a German equatorial mount, the telescope and counterweight should balance each other (almost!) and the telescope front and rear should balance each other across the declination axis. Celestron gives clear instructions to guide the user through these necessary steps.

Rough-point the telescope. Release the double sets of inconveniently-located clutches on both axes so the telescope moves freely. Locate the object and tighten all four clutches. Make small corrections with slow motion controls near the R.A. and Dec. motors. Control fine adjustments by setting the electronics box to the desired motor speed.

Elaborate and Precise

Software Bisque ventured into hardware design and manufacture with its robotic Paramount GT-1100S German equatorial mount, designed for control via computer instructions. The GT-1100S is controlled by the user's computer at the telescope or via the Internet from anywhere. This offers great advantages as well as disadvantages.

Although the Paramount is designed for permanent installation, it can be transported. It's set to use in a latitude range of 18° to 50° without an optional extension.

Careful instructions guide the user through setup and balancing. Exact specifications — including the number of full turns before the cables tear — dictate cable length and placement not only between mount and computer, but also between camera and computer.

A suite of software applications must be installed and learned. Setting up the Paramount requires using the software to both map residual flexure in the mount (found in all mounts) and for polar alignment. When done thoroughly and carefully, the GT-1100S mount points anywhere in the sky with one arcminute accuracy (about 1/30 of the diameter of the moon).

The Paramount is designed for electronic imaging, including CCD and video. These imaging activities, along with the software that controls telescope motions, make the Paramount unique. Advanced observers will undoubtedly appreciate this elaborate and precise mount.

After-market telescope mounts offer wonderful observational opportunities. When shopping for a giant mount, consider ease of setup, purpose, and computer acumen. (You want to avoid relearning how to use the mount each time.)

Given the mounts now available, the observational rewards are a stable view and fine images — and those are very sweet.

For more than three decades, Steve Edberg has been using a surgeon's touch on floppy telescope mounts to make them work.

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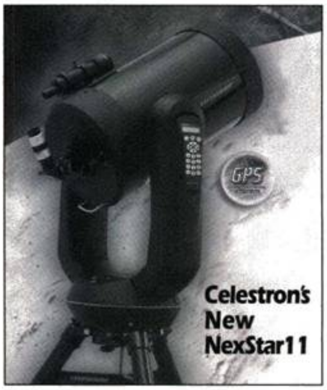

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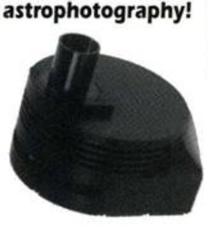

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*step rings for other sizes available.

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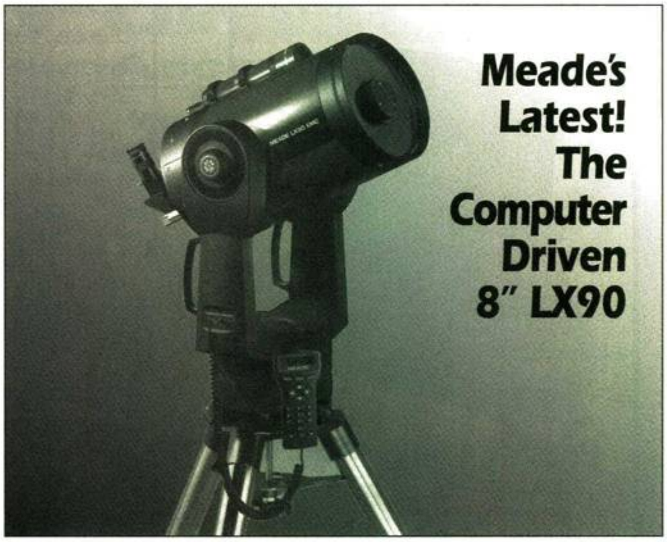

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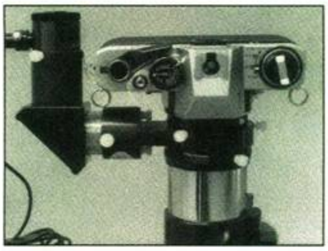

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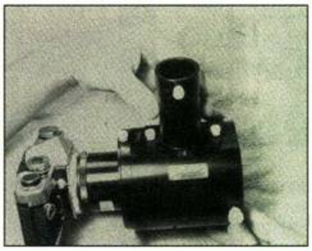

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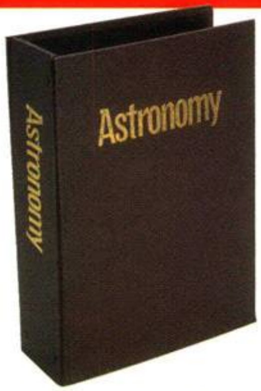

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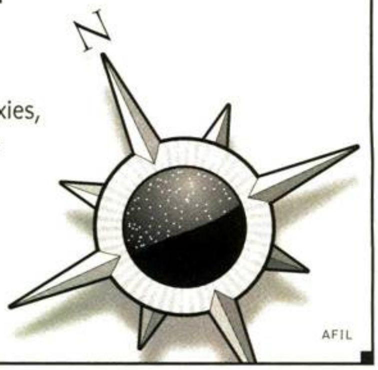

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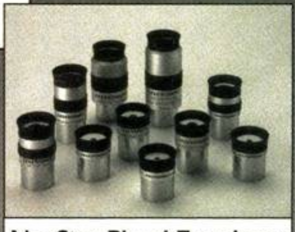

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How do I get started with basic astrophotography? Approximately how much will the essentials cost me? — *Todd Anderson, Tishomingo, Oklahoma*

Astrophotography covers a wide variety of interests, and your budget can range from $100 to about $20,000 or more. I prefer to stay near the low end of the cost spectrum. To make the most of your foray into astrophotography, be sure to educate yourself. Read lots of good books and magazine articles first.

One good way to start is by aiming a camera into the eyepiece of your telescope to take pictures of the moon. This is called "afocal coupling" and works well with both film and digital cameras. The camera can stand on its own tripod or be held on a bracket. Believe it or not, my best moon pictures were taken this way.

Another good first step is to take pictures of the constellations. You'll need a camera that gives you full manual control, preferably one that doesn't consume battery power during long exposures. A 1970s-era SLR is ideal; modern auto-everything cameras usually aren't as suitable. (See if your relatives have an old SLR stashed away in a closet.) The camera should have a fast 50mm lens (maybe f/1.8 to f/2.8) rather than the slow zooms that are now in vogue.

Load the camera with Elite Chrome 200 slide film, put it on a tripod, and attach a cable shutter release. Aim it at the starry sky and expose for 20 seconds. Your slides will show stars to 7th magnitude with vivid colors.

Why slide film? Local labs generally don't know how to print astronomical negatives. With slides, what you see is what you get, and you can always get someone to make a print afterward. Best of all, you can use your own scanner to make custom digital prints with your computer.

The next step up is to "piggyback" your camera, with a telephoto lens, on an equatorial-mounted, motor-driven telescope. If you plan to use a computerized telescope, be sure to get the equatorial wedge to go with it, so the image won't twist while tracking. Then make long exposures of stars, clusters, and nebulae through a telephoto lens. After all these years, this is still my favorite mode of astrophotography.

Through-the-telescope photography of planets and deep-sky objects is the hardest kind of astrophotography. To get good results, you'll have to invest a lot of money — and time. Bear in mind that the pictures you see in *Astronomy* are the work of people who have spent years developing their skill.

Practice makes perfect. Hard work and patience can turn fuzzy bloopers into true gems of M31, the Big Dipper, star trails, the Pleiades star cluster, and Cassiopeia.

From top: George Greaney, Bill and Sally Fletcher, Joshua Vaughan, Tony Hallas, Bill and Sally Fletcher

— Michael Covington is the author of Astrophotography for the Amateur *(Cambridge University Press, 1999). You can visit him on the Web at www.covingtoninnovations.com.*

How could Mars ever have been warm enough to sustain liquid water on its surface? — *Elden Miller, Elsinore, Missouri*

The most likely scenario is that a primordial Mars — more than 3,500 million years ago — had a much thicker atmosphere of CO_2 (carbon dioxide), due to increased volcanic activity. This would have two effects. First, by raising the air pressure, liquid water would become much more stable on the surface, and would not evaporate so rapidly. Second, it would produce a "greenhouse effect," which warms the air so that water wouldn't freeze in the first place.

Recent studies show that such a martian atmosphere would have been cloudy, helping to hold in the heat and raising the temperature even further. Thus, for the first 1,000 million years or so, Mars may have been able to sustain a much more fluvial surface environment, with rivers flowing into lakes, seas, and oceans. Many craters and low areas may have even had water emptying into them, which could explain the layered sedimentary deposits recently publicized by members of the Mars Global Surveyor team (see AstroNews, March 2001). — *William K. Hartmann, Mars Global Surveyor Imaging Team, Planetary Science Institute*

Is the Large Magellanic Cloud the nearest galaxy to the Milky Way? — *Owen D. Camp, Cairo, New York*

The Milky Way Galaxy is one amongst a collection of galaxies called the Local Group. The Local Group contains approximately 35 members — mostly small satellites called dwarf galaxies. The Magellanic Clouds, the Milky Way, and Andromeda are the brightest members of the bunch.

Though very close to the Milky Way, the Magellanic Clouds are not the closest. This distinction belongs to a diminutive dwarf spheroidal galaxy called Sagittarius. Discovered a few years ago, Sagittarius is about twice as close as either of the Magellanic Clouds and seems to be colliding with the far side of the Milky Way. Just beyond Sagittarius lies the Large Magellanic Cloud, along with its slightly more distant neighbor, the Small Magellanic Cloud. — *Chris Conselice, Space Telescope Science Institute*

If the sun exploded this very second, how long would it take for the effects to reach us? What might those effects be? — *Steven Bugler, Lowell, Massachusetts*

For me, this would be the worst news since the Green Bay Packers lost the 1998 Super Bowl to the Denver Broncos. If the sun suddenly blew up, we'd have about 8 minutes and 20 seconds (the light travel time between the sun and Earth) to live. "News" of the explosion would reach us in the form of a blazing burst of light and intense heat that would immediately incinerate our atmosphere and vaporize the oceans and all living things on the sun-facing side of the planet. Ferocious supersonic winds, caused by an atmosphere trying to regain equilibrium, would quickly spread disaster to the nightside of Earth as well. The surface of our planet would be scoured of life within hours. And we'd all be dead before the *New York Times* had time to cover the impending disaster.

A wet Mars? Signs say yes, but astronomers are still trying to understand how.

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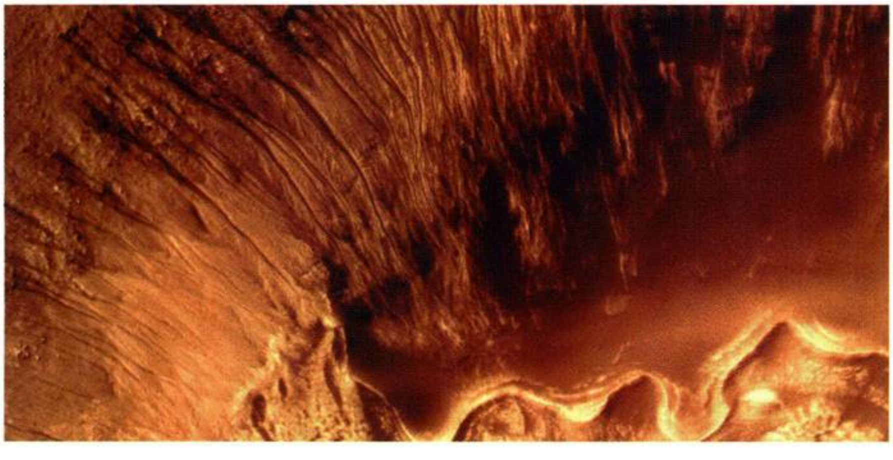
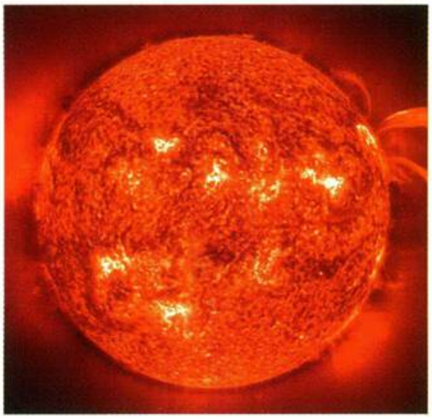


Fortunately for us, the sun isn't nearly massive enough to blow up in this kind of explosion. But if one harbors a macabre interest in such things, one can easily envision other solar disasters that are likely to never happen. For example, if the sun suddenly collapsed into a black hole, we'd have 8 minutes and 20 seconds before all of the sun's life-sustaining light and heat would disappear.



Sure, the sun is prone to frequent outbursts. But it's not going to blow up any time soon.

NASA/ESA/EIT Consortium

Many people probably think that Earth would get sucked into the black hole. But because the sun's mass would remain the same, Earth would maintain its current orbit for hundreds of billions of years. It would do so, however, as an airless, nearly lifeless ball of rock and ice.

Earth's surface would freeze within a year, and the oceans would solidify in about a million years. Still, microbial life might survive hundreds of millions of years, deep in Earth's crust, warmed by geothermal heating. — *Robert Naeye, Astronomical Society of the Pacific (Special thanks to Greg Laughlin, NASA/Ames Research Center)*

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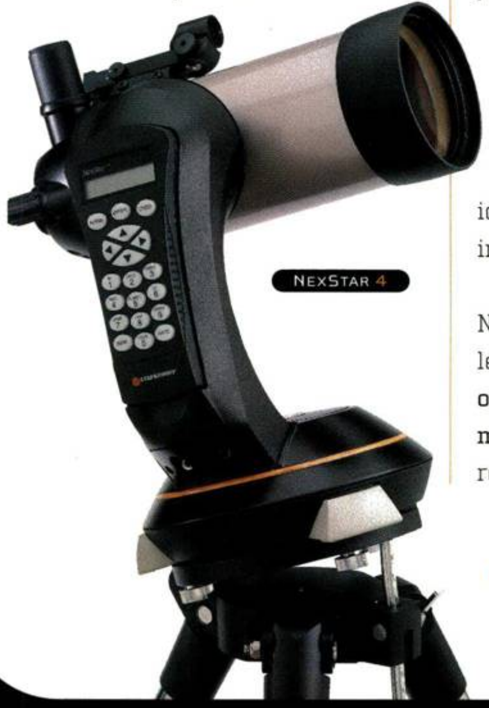
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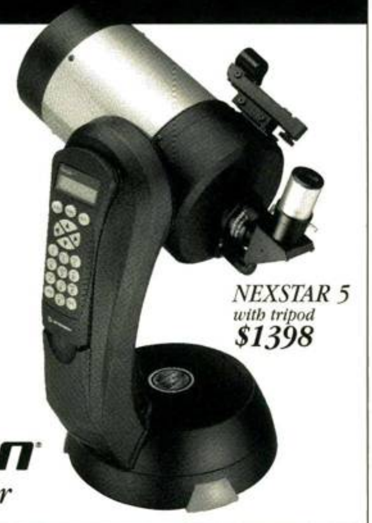

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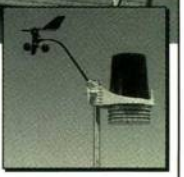

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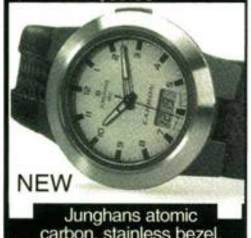

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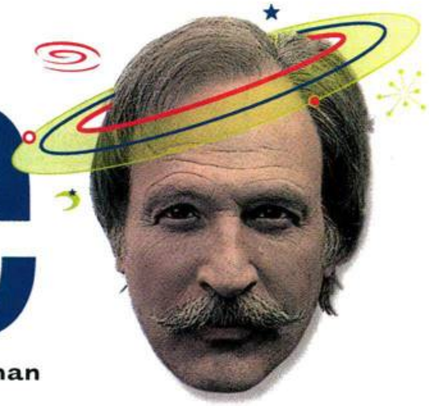

by Bob Berman

Has Anyone Tasted the Moon?

Ah, May; it holds the scent of new grass intermingled with dawn's symphony of songbirds. No month is a better reminder of how life's full enjoyment entails all of the senses.

But this is not for astronomers. Our pastime or profession is one of the few in which knowledge arrives via the single sense of sight.

We cannot smell, hear, taste, or (except for that brief delivery of moon rocks 30 years ago) touch the objects of our fascination.

Birdwatchers listen as much as look. Gourmands taste and smell more than anything else. We simply stare. Of course, the public imagines that we also hear the cosmos via radio telescopes. The media perpetuates this myth by invariably portraying radio astronomers wearing headsets, as if they are downloading the latest Napster music from Sagittarius A. And if not headsets, then having ears cocked toward wall-mounted speakers whose hisses and crackles suddenly snap everyone to attention by changing to an ominous drone. Few lay people know that radio waves are just another form of light (electromagnetic radiation) and that radio telescopes cannot detect sounds of any kind.

No, ours is a medium of light alone. And even here, we're trapped within provincial boundaries. Our eyes are blind to all wavelengths except for the narrow visible spectrum between 4,000 and 7,000 angstroms where the sun most strongly emits its energy. In a way, we view the universe only with the sun's sanction: We're blind to gamma rays, x rays, microwaves, everything that the sun either barely emits or that is blocked by our atmosphere. Since our eyes evolved to see by daylight, backyard astronomers are hardwired to scan the universe with a built-in sun-bias. We're far more capable of perceiving sunlike objects (or things like planets that bask in sunlight) than anything else.

Imagine a universe we could grasp with all our other senses. Well, not all of them; taste is probably ruled out. Who'd want to lick Pluto? I doubt a single researcher with access to any of the 842 pounds of lunar soil and rock ever thought, what the heck, let's see how the moon tastes. But wouldn't you pop a little crunchy bit of moon dust into your mouth just to know that you were the only person on Earth who had eaten the moon?

I have a wonderful two-pound iron meteorite, an asteroid fragment that landed in Africa a couple of centuries ago. Well, how do asteroids taste? I confess I once gave it a quick lick to find out. Answer: Not Recommended.

What I'd really love to do is run my hands through lunar regolith, the baby-fine soil that completely covers the moon's surface. It's supposed to be the finest powder imaginable, like bakers' flour. The astronauts couldn't do it, of course, since they had to wear space gloves. And not enough has ever been assembled in one place to play in. Some future lunar colonists would have to put a protective bubble over a flat piece of ground and pump it with air, and only then could they let the kids roll around in it.

Not much else in space cries out to be fondled. The solar system abounds with ice and cold rock, which hardly offer a novel tactile experience. Still, if you want to place your fingers on a smooth piece of moon rock, you can do it in the Smithsonian Air and Space Museum in Washington, D.C.

Even more intriguing would be to hear the sounds of the solar system. The sun, for example, is like a giant subwoofer, with enormous high-amplitude pulsations of various cycles. Some of those noises and beats would definitely be heard all the way to Earth if there were an interplanetary medium to carry the waves. In fact, "heard" is an understatement; the sun would be a deafening boom box, blaring intriguing combinations of regular deep tones punctuated by Latin-style flourishes. And the melody might change during eclipses, or at least lower its volume.

The vacuum of space insulates such potential sound sources from our ears: A firecracker would be silent if it went off a few inches from an astronaut's head. That explains why the huge explosion aboard Apollo 13 seemed so muffled; the percussion was largely directed outward into space. If there had been air around the ship, those astronauts would have heard a huge blast. They probably wouldn't have sounded so calm when they said, "Houston, we've got a problem."

Planets like Saturn with constant fierce winds over 500 miles-per-hour must experience a continuous terrifying roar. Jupiter's ultra-powerful lightning storms and Europa's ice sheets brushing into each other would resound with extremely loud and complex noises. It might be fun for a musically creative astronomer to synthesize such effects and play them as background accompaniment when visitors peer at Jupiter in the eyepiece.

For an even more enveloping experience, one could add the smells of the jovian system. Don't expect roses. This is a region even rats would avoid, arguably the foulest-smelling place in the known universe, except for certain sections of the New Jersey Turnpike. A health inspector would be happy to approve the clean, sanitary conditions of Mercury and might even be okay with the distinctive but still tolerable sulfuric-acid odors of venusian clouds. But Jupiter? P-U!

First you've got Io's volcanoes continually spewing sulfur fumes into space, bathing the entire region in the aroma of stink bombs. Then Jupiter's atmosphere smells rife with methane (swamp gas) and ammonia. The place resembles a dormitory where the dinner menu included beans. No wonder the most likely place for life in that sector would be under the ice sheets within the oceans of Europa, where sensible sea-dwelling creatures would avoid all unpleasant odors.

In most cases, unique local conditions would produce sensory surprises. Mars, now brilliant after 11 P.M. as it approaches its opposition next month, often has 100-mile-per-hour winds. These would deliver sensory extremes on Earth in the form of earsplitting hurricane howls and brute tactile forces that could knock a person to the ground. Not so on Mars. There, the very low air pressure would make those same winds as soft and quiet as an earthly breeze. Moreover, sound barely travels on Mars except through the ground itself. Despite an active martian atmosphere, a helmetless visitor would feel, smell, and hear very little.

Our senses specifically evolved to access terrestrial conditions: Going anywhere else would likely punish us with sensory extremes, exposing us to either unpleasant overload or deprivation. So while it would be astronomically intriguing to expand our receptors beyond sight alone, it probably wouldn't be much fun. All of which takes us back to May's reminder that there's no place like home, and no time like spring to bring us to our senses. ◼

Bob Berman is the author of several books, including Secrets of the Night Sky.

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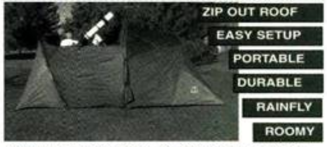

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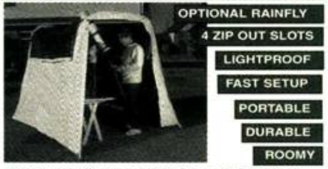

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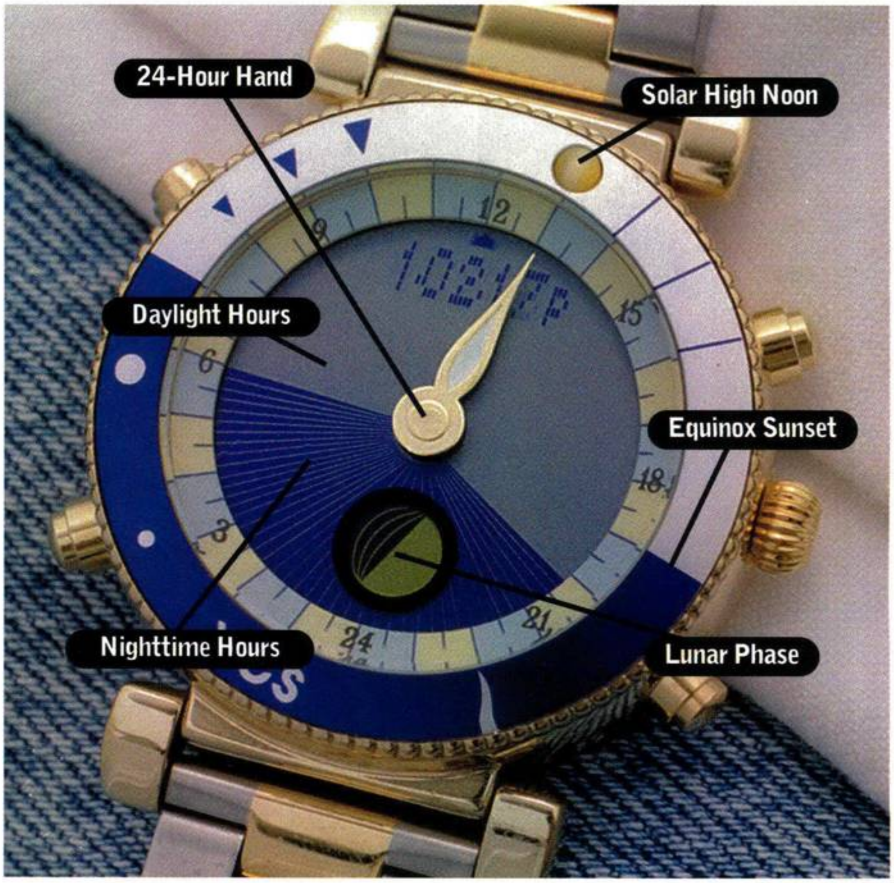
Yes Watches, 2269 Chestnut St., No. 168, San Francisco, CA 94123; phone, (415) 883-8332; fax, (415) 883-7115, websites, http://www.yeswatch.com, http://www.windandweather.com http://www.astronomy.com: $229.



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▶ In the 1700s, aristocrats owned mechanical solar-system models called orreries, which depicted model clockworks of the known planets — Mercury through Saturn. The addition of a half armillary sphere over an orrery became known as a grand orrery. While advanced software charts the planets with fine precision, orreries help kindle a modern fascination of these almost forgotten devices.

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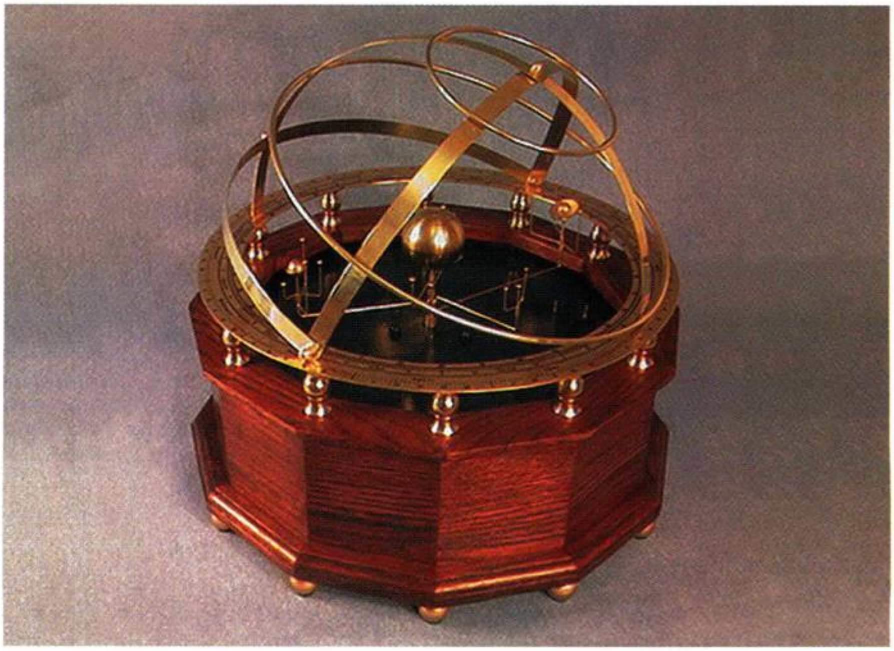

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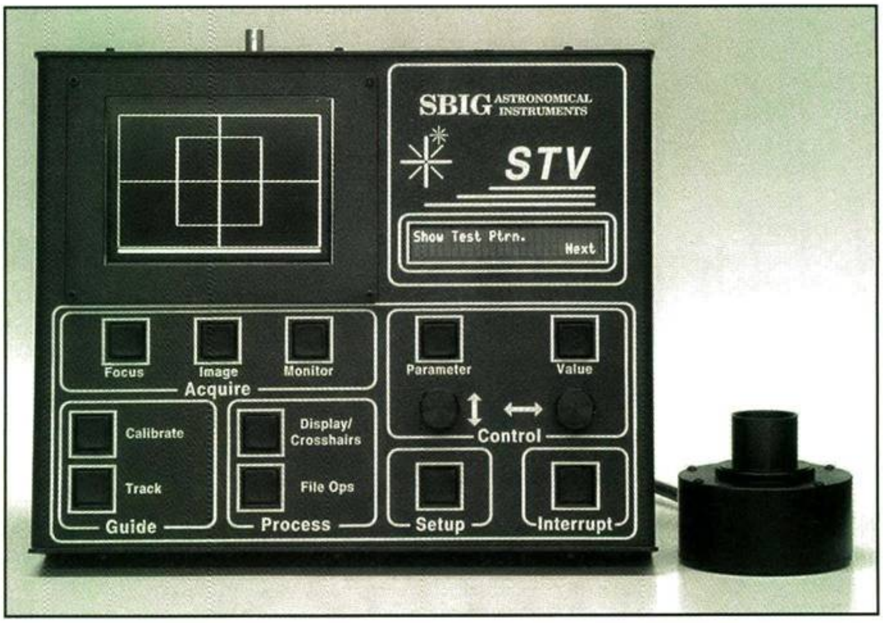
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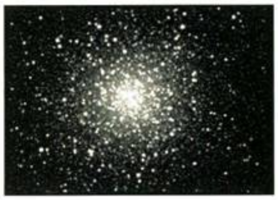

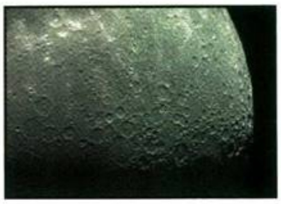

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BOOKS

Einstein in Love: A Scientific Romance

Dennis Overbye, 416 pages, Viking/Penguin Putnam, New York, 2000; ISBN 0-670-89430-3; hardcover, $27.95.

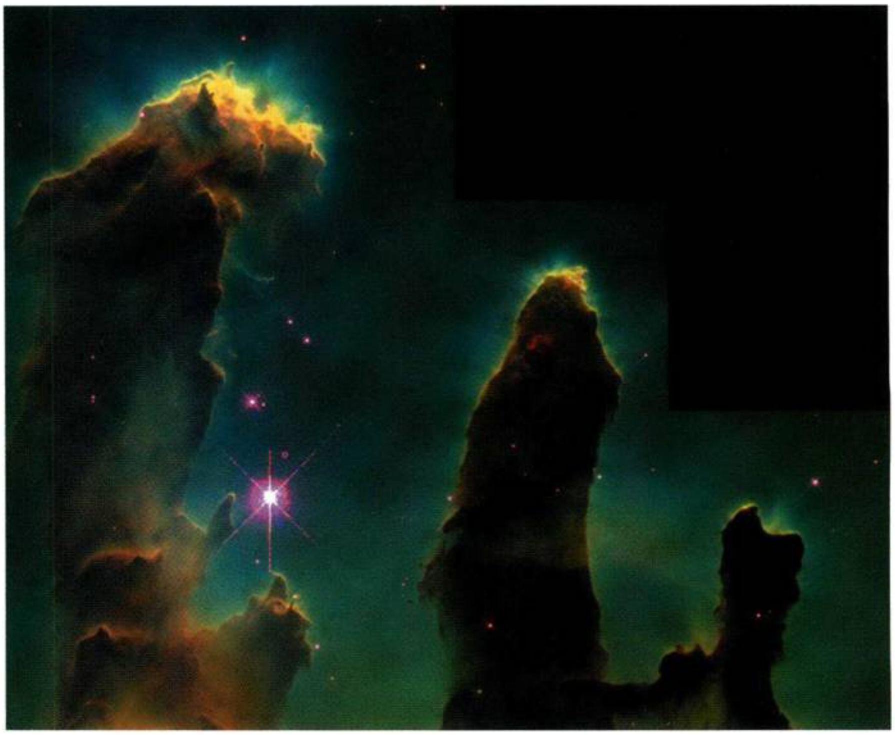
Einstein's Brainchild: Relativity Made Relatively Easy

Barry Parker, 280 pages, Prometheus Books, Amherst, NY, 2000; ISBN 1-57392-857-7, hardcover, $28.

▶ As advertised in the title, Overbye's *Einstein in Love: A Scientific Romance* is a love story. In fact, it is two very different love stories. One deals with the often tortuous, sometimes sublime, relationship between the young Einstein and his fellow student and first wife, Mileva Maric. The other describes his equally tortuous and sublime relationship with physics.

In both affairs, Einstein shows himself to be a passionate, articulate lover, willing to take great risks and court great failure. Yet of the two, he is clearly more comfortable in the arms of Mother Nature than with the tangible women in his life.

As Overbye points out, Einstein's story turns on its head the tired cliché of the wild dreamer who needs a sensible woman to offer solid support. In Einstein's case, physics provides solidity against the turmoil of human relationships. "It was with physics that he needed to ground himself in the surreal fog of desire," writes Overbye. "It was physics that offered a small, ordered closet in which to hide."

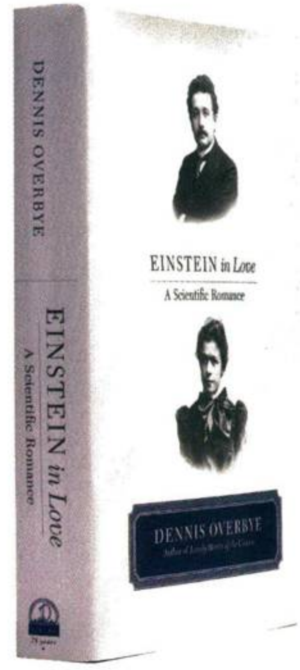


M16, the Eagle Nebula. STScI, NASA

What Einstein found in that closet was anything but comforting to some, of course. Among other things, he warped space, distorted time, and showed that matter was only a concentrated form of energy. But compared to the constantly shifting landscape of his emotional life, the undulations of spacetime were based on relatively solid scientific ground.

Indeed, Einstein's difficult relationship with Mileva has all the ingredients of a soap opera: teenagers in love kept apart by disapproving parents; Einstein's mother scolding him over his affair with a girl who is clearly of the "wrong kind" — a girl who's not even Jewish!

Love conquers, if not all, at least the protesting parents. Einstein calls his beloved "my little street urchin, my little veranda, my everything!" He sends her an outline of his foot so she can knit him socks. They conceive a child, who disappears without a trace after the couple gives it away. They later marry, have two sons, and grow distant. There is an ugly divorce.



Overbye lets us in on all the gritty details of Einstein's separation — the meetings with lawyers, the hateful exchanges, the tearful good-byes with his sons as they go to live with their mother. There is a new lover, a woman who buys Einstein a hairbrush and toothbrush, and tells him to use them. He marries a second time, and things get easier, if not necessarily simpler.

On a parallel trajectory, Einstein's love affair with physics seems to start off rather hopelessly. Unable to get a job, Einstein takes

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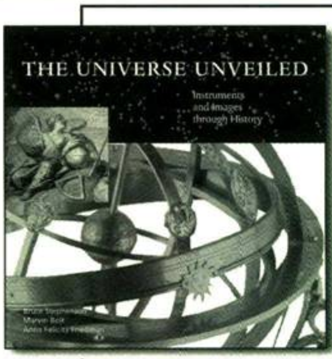
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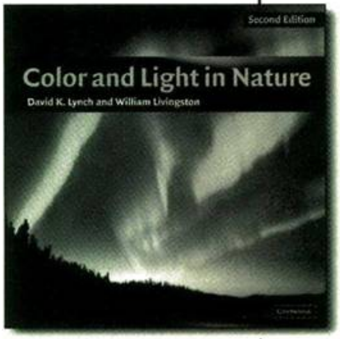
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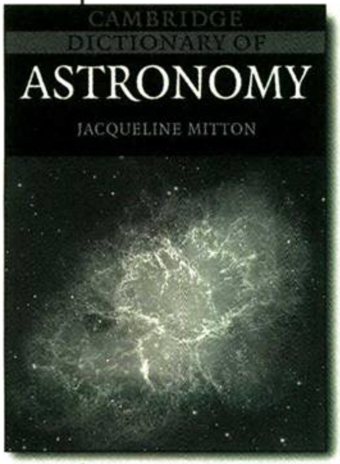
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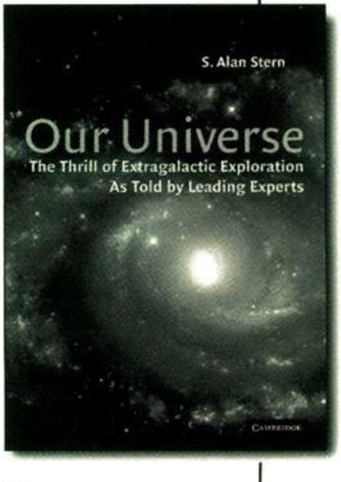
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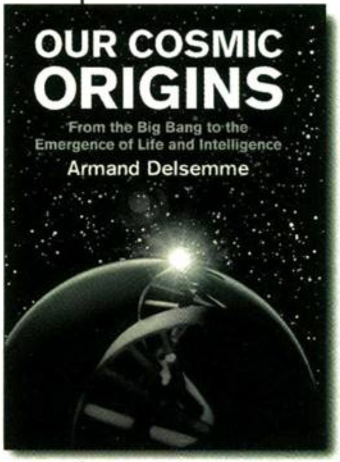
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low-paying work as a tutor. Most of the time, prospective employers don't give him the courtesy of a rejection. These are old stories, but filled out by Overbye in remarkable, vivid detail.

Obstacles don't deter Einstein in physics any more than they did in love. He's far too smitten: "Under the influence of this wonderful piece of work I am filled with such happiness and such joy," he says. The workings of nature appear to him as "staggering," "stunning," "beautiful." He confesses to a friend, "I really believe that I discovered a piece of the truth."

Fame, when it came, came quickly.

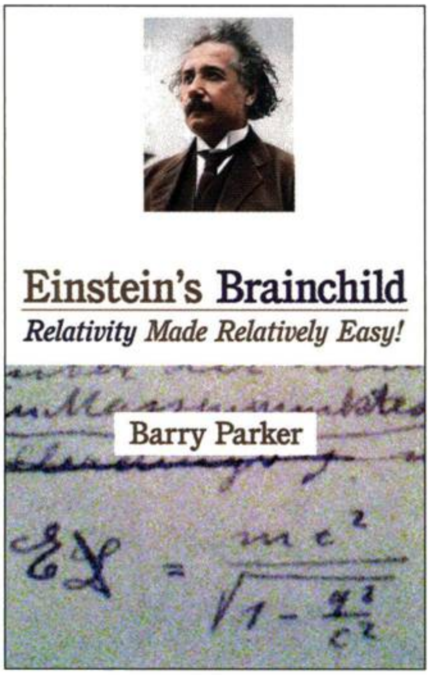
"In his more reflective moments," Overbye tells us, "[Einstein] found it a little spooky how quickly the European physics community was willing to confer on him the status of genius." And later: "Whereas [Einstein] once had been a man without a country, he was now a member of a society almost above country, with a passport stamped by God."

For awhile, Einstein feared that he would not live up to his newly won superstar billing: "The Berliners are betting on me as on a prime laying hen," he writes. "I am not certain I can still lay eggs."

Yet Einstein does lay more golden eggs, although fewer as time passes. There is a poignancy here. As Einstein laments to a friend years later: "Truly new things one finds only in one's youth. Later one becomes more experienced, more famous, and dumber."

Overbye not only lets us in on Einstein's exhilaration and despair in love and physics, he also explains in clear detail Einstein's scientific contributions and the puzzles that led him there: For example, the early understanding of "black body" radiation and the "ultraviolet catastrophe," which drove Einstein to consider that radiation came in discrete increments, or quanta — a discovery for which he won the 1921 Nobel prize for physics.

At the time, nobody paid attention. He was only a patent clerk, dabbling in physics. Again and again, Einstein gave physical meaning to the mathematics of other scientists, who often didn't dare follow their own ideas to their logical — if bizarre — conclusions. The story of how Einstein painstakingly untied the knots in his theory of gravity as curved spacetime is both suspenseful and satisfying, and Overbye's analogies are unusually clear and often delightful. When all was said and done, Einstein showed that "gravity was like an itch in spacetime that got worse the more it was scratched."



This is not a light read, but an exhaustive scholarly work of research. Overbye read everything and went everywhere, retracing Einstein's steps, haunting his haunts, reconstructing in fine detail the scenery and subtext of Einstein's complex life. Sometimes Overbye tells more than readers want to know, such as listing the music Einstein played when visiting various friends or acquaintances.

But *Einstein in Love* is an honest book that doesn't try to bamboozle the reader with trumped up emotions and contrived situations. Overbye clearly separates fact from informed speculation. "It might have been on one of those cozy Sunday visits, late in May, that Mileva first voiced her concern to [Einstein] that she might be pregnant," he says, typically.

Einstein in Love is an intimate encounter with a most interesting man and his even more interesting science — not one you're likely to soon forget.

By comparison, Barry Parker's *Einstein's Brainchild: Relativity Made Relatively Easy*, barely skims the surface. At best, it's a clear, simple review of relativity, literate if not literary. It's Mr. Rogers meets Dr. Einstein, frequently conveyed in charmless baby talk about a scientist and his work: "To see why, let's use a diagram…" "It's important to remember …" "Let's now turn to …"

The story of Einstein's relationships with Mileva and physics covers the same ground as Overbye's book, but almost in cartoon fashion. Parker dismisses Mileva — a complex, intelligent woman — as a moody whiner, conveying no sense of Einstein's part in destroying the relationship.

As for physics, much of Parker's book is not about relativity at all. Descriptions of the Big Bang, formation of the elements, inflation, and Grand Unified Theories are tangential to say the least. Many of his explanations fall short of clear explanation. The author tells us cryptically that "crazy things would happen," or matter would "act strangely," but doesn't tell us why or how. Also, many of the quotations attributed to Einstein have no references and don't ring true, as opposed to Overbye's carefully annotated quotes.

Einstein's Brainchild is nicely organized and certainly gives readers a useful review of the essentials of relativity, along with some charming personal interludes. But overall, it's probably not fair to put Parker's book next to Overbye's. Instead, the two might serve as bookends: *Einstein's Brainchild* for the beginner; *Einstein in Love* for the connoisseur. — *K.C. Cole,* Astronomy *Editorial Advisory Board member and author of* The Hole in the Universe: How Scientists Peered Over the Edge of Emptiness and Found Everything

The Universe Unveiled: Instruments and Images through History

Edited by Bruce Stephenson, Marvin Bolt, and Anna Felicity Friedman, 152 pages, Cambridge University Press, New York, 2000; ISBN 0-521-79143-X, hardcover, $29.95.

▶ Editors Stephenson, Bolt, and Friedman, all connected with the History of Astronomy Department at Chicago's Adler Planetarium and Astronomy Museum, combined their skills to pro-

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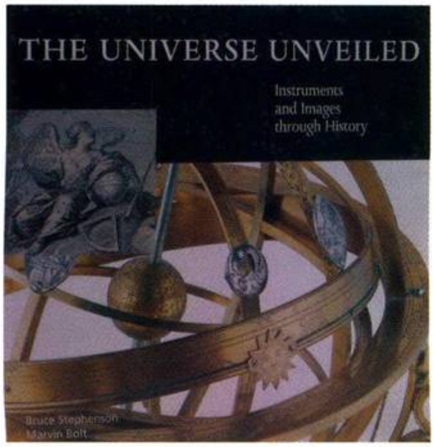
duce a history of astronomy worthy of anyone's library. Filled with more than 270 color images and illustrations, *The Universe Unveiled* documents the evolution of thought and the instruments that provided vital clues to early astronomers. Along the way, readers witness the depths to which ancient thinkers perceived their world and the cosmos beyond it.

Four main chapters describe the stages of the awakening of scientific endeavors. Each is loaded with examples of artifacts from cultures and countries around the world. The book notes everything from primitive telescopes and the earliest constellation maps and drawings — often made by illustrators using only written descriptions — to the huge range of ingenious sundials, orreries, astrolabes, and armillary spheres. They were the tools used to chart lunar, solar, planetary, and stellar movements.

As humans became more interested in celestial phenomena, they devised ways to use them to accurately measure time. As timekeeping improved, navigational equipment advanced and human exploration expanded. These innovations led to a deeper understanding of Earth and the heavens. Later scientific instruments are pictured here, too. Captions don't clutter the pages; instead, the editors include references to illustrations in the text. Readers seeking specific details on an object can consult the list of illustrations at the back of the book.

The development of a standardized nomenclature to explain discoveries ran parallel to the technological advances. *The Universe Unveiled* contains a glossary and bibliography (including websites). Think of this book as an armchair tour of the history of astronomical equipment.



However, the tour ends abruptly with the realization that the universe contains billions of galaxies — an awareness that parallels the decline of the ornate and symbolic artistry of earlier instruments and illustrations. It may seem to some that what we gained in scientific understanding, we lost in aesthetic appeal. But that is not the theme of this book.

Unveiled artfully explores the unbroken link we moderns share with ancient astronomers, explorers, and scientists: Curiosity leads us to make sense of our world. In an age of 8-meter telescopes, satellite communications, and CCD imagery, it's important to remember that what we call state of the art today will someday seem as quaint as orreries do now. Yet the ingenuity of those who came before us shines through on each page of this book.

The Universe Unveiled reveals the human spirit underlying the search for knowledge and understanding. Only the tools have changed. — *Carol Ryback, associate editor*

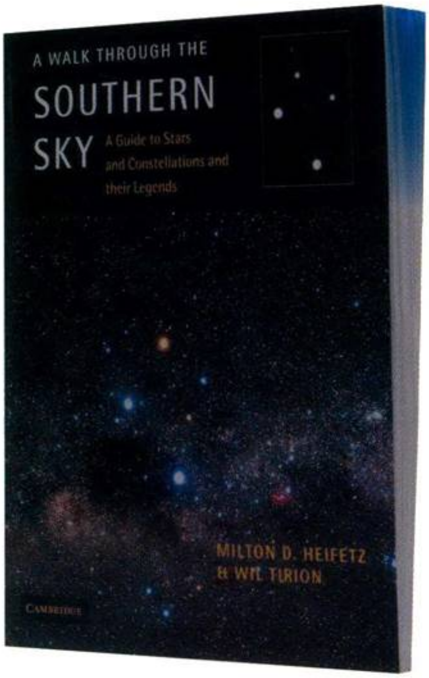
A Walk Through the Southern Sky: a Guide to Stars and Constellations and their Legends

Milton D. Heifetz and Wil Tirion, 105 pages, Cambridge University Press, New York, 2000; ISBN 0-521-66514-0; paperback, $14.95.

▶ Few people would regard an astronomical guidebook as an enjoyable read, but if you take *A Walk Through the Southern Sky* with Heifetz and Tirion, your opinion may change as quickly as mine did.

This fantastic book for beginners makes learning the constellations and their legends relatively painless. It also explains the physics that readers will need to take the trip with Heifetz and Tirion. The compelling mix presents its message with simple drawings and helpful explanations of how to navigate the southern sky, even if you don't know the south end of a telescope from the north.

A Walk Through the Southern Sky first explains the basics of stellar distances and brightnesses before moving into how to identify constellations. Readers will most likely spend the majority of their time on "A Walk Through the Heavens." In this main chapter, the stargazer moves across the sky, starting with the Southern Cross — one of the easiest southern constellations to find. Heifetz and Tirion then direct readers to the legends section to learn why the stars of each constellation relate to one another as a group. The book is extremely helpful to naked-eye observers.


A WALK THROUGH THE
SOUTHERN SKY
A Guide to Stars and Constellations and their Legends
MILTON D. HEIFETZ & WIL TIRION
CAMBRIDGE

The final chapter discusses circumpolar constellations, star colors, paths of the planets, and tips on binocular use. Tables listing important navigational stars, minor constellations, and how and where to look for planets each month until 2006 round out this easy-to-use guide.

I don't live in the Southern Hemisphere, but thanks to Heifetz and Tirion, I can't wait to travel there — if only to walk through the southern skies with their book in hand. — *C.R.*

The Little Book of Stars

James B. Kaler, 184 pages, Copernicus Books, New York, 2001; ISBN 0-387-95005-2; hardcover, $20.

▶ Popular songs often refer longingly to stars, and Kaler's well-written *Little Book* is music to any amateur astronomer. The author, an astronomy

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- **"Universe in the Classroom 2001," a workshop for grade 3-12 teachers, July 16-17**
- **"The High-Energy Universe at Sharp Focus: Chandra Science," a science symposium for professional astronomers, July 16-18**

Image courtesy of the European Southern Observatory

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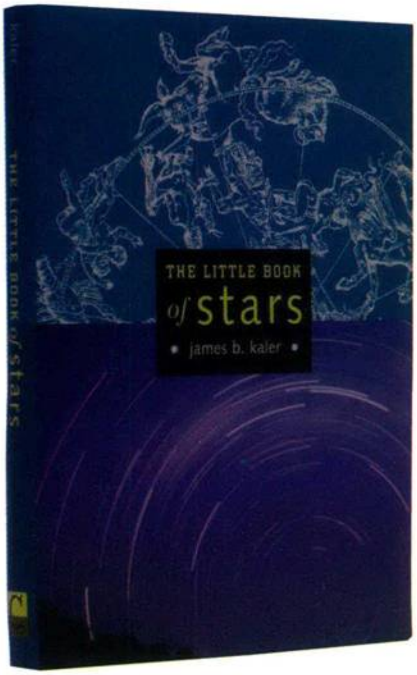
professor at the University of Illinois, moves up the scale from single stars to double stars, double-double stars, open clusters, globular clusters, galaxies, and superclusters — then back down, grouping stars into seven types from the hottest to the coolest: O, B, A, F, G, K, M. (Classes L and T have been added to the end.) Astronomers distinguish a B star from, say, an A by its bar-code pattern of dark absorption lines superimposed on the rainbow visible spectrum. The lines are caused by various gases at different temperatures surrounding each star. "To allow for better discrimination, the system was decimalized. As temperature declines, Class A is broken down from A0 through A9, which smoothly continues to F0 through F9, and so on."

By simplifying, Kaler reveals symmetries that wouldn't occur to most readers. While the inviting title and 5" by 7" format may lure newcomers to astronomy, they might find stellar phenomena such as supernovae poorly explained, and other descriptions require the reader to negotiate intermediate chemistry and physics. For example, extremely hot, dying stars that toss off giant clouds of gas produce ultraviolet light that is so energetic "it strips the atoms in its surrounding nebula of their electrons, ionizing the gas. When the atoms recapture the electrons, much of the energy is released in the visual part of the spectrum, causing the nebula to glow. Because they release energy instead of absorbing it, the glowing gases of planetary nebulae display narrow emissions — emission lines — at the same wavelengths at which stars show absorption lines."

Kaler explains how hydrogen atoms fuse into helium in the cores of stars like the sun. In bigger, brighter stars, fusion creates all the heavier elements necessary for life as we know it, and scatters the atoms of nitrogen, oxygen, and iron — like seeds to the cosmic winds.

The book has one shortcoming: Some topics seem oddly organized, with a chapter on constellations and astrology sandwiched between particle physics and fusion reactions.

Overall, however, *The Little Book* goes a long way toward clarifying the muddle of stellar classification. For amateur astronomers looking to add a concise, helpful book on stars to their library, Kaler has written a little book that should. — *Rex Graham, senior editor*



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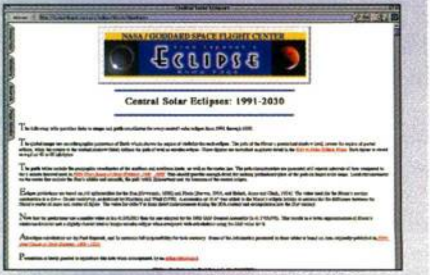
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Fred Espenak's Eclipse Page

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http://sunearth.gsfc.nasa.gov/eclipse/SEpath/SEpath.html

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Rockland Community College in Suffern, New York, is the setting for the **Northeast Astronomy Forum and Telescope Show, May 5–6**, sponsored by *Astronomy* magazine and the Rockland Astronomy Club. The forum will feature lectures by amateur and professional astronomers, childrens' activities, Starlab demonstrations, an ATM display by Springfield Telescope Makers, and CCD imaging workshops conducted by Richard Berry, former editor of *Astronomy*. More than 70 vendors will display their wares while door and raffle prizes will be awarded to lucky attendees. For more information, contact Alan Traino at (973) 427–2020; e-mail, alan3203@sprynet.com; website, www.rocklandastronomy.com.

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THROUGH MAY

Star Struck — 1,000 Years of the Art and Science of Astronomy

Huntington Library, San Marino, California. Exhibition of rare books and manuscripts from the Huntington's collection, along with a moon rock from NASA and deep-space photos from JPL. For more information, phone (626) 405–2142, or view the Huntington's website, http://www.huntington.org.

THROUGH JUNE 4

Creation, Constellations, and the Cosmos

Norton Simon Museum, Pasadena, California. This art exhibition depicts how artists from Western and Eastern traditions have defined spiritual connections with the cosmos within various cultural traditions and artistic media. For more information, contact (626) 449–6840; website, http://www.nortonsimon.org.

MAY 2

Silicon Valley Astronomy Lecture Series

Foothill College, Los Altos Hills, California. 7 P.M. Vera Rubin of the Carnegie Institution of Washington will speak on "**What's the Matter in the Universe: Galaxies and Dark Matter**." Sponsored by NASA Ames Research Center, Foothill College Astronomy Program, the SETI Institute, and the Astronomical Society of the Pacific. For more information, call the series hotline at (650) 949–7888.

MAY 4–5

Annual Convention of the North Central Region of the Astronomical League

Ramada Inn, Green Bay, Wisconsin. For more information, contact Ron Parmentier, 161 Rosemont Drive, Green Bay, WI 54301; website, http://www.npmas.com/ncral2001.html.

MAY 5

Astronomy Day Celebration

Beaver Meadow Observatory, North Java, New York. Activities include solar viewing, telescope clinics, demonstrations and workshops, along with lectures and night sky viewing. For more information, contact (716) 457–3104; e-mail, astronomyday@juno.com; website, http://members.aol.com/BuffAstro.

MAY 8

Astronomy Symposium

Reno, Nevada. Lecture by NASA Astronaut Thomas Jones. Sponsored by the Astronomical Society of Nevada. Contact Bob Graf, (775) 329–8809; e-mail, syzygy5@hotmail.com; website, http://www.rmss.org/rmss2001.htm.

MAY 12

STARCONN

Wesleyan University, Middletown, Connecticut. For information, contact the Astronomical Society of Greater Hartford, P.O. Box 2271, Hartford, CT 06145-2271; (860) 284–1099; e-mail, asgh2001@hotmail.com; website, http://www.asgh.org. For early registration, write to Carl Koplin, 54 Candlewood Dr., Tolland, CT 06084.

MAY 13–20

Texas Star Party

Prude Ranch, near Fort Davis, Texas. For further information, contact Anne Adkins, 4812 Twin Valley Drive, Austin, TX 78731; (512) 451–0339; e-mail, tspreg@metronet.com; website, http://www.metronet.com/~tsp/index1.html.

MAY 18

Explorer Lecture Series: Charles Liu — The Farthest Stars

Cleveland Museum of Natural History, Cleveland, Ohio. Stroll through the galleries, meet speakers and curators, enjoy live music, visit the planetarium, participate in book signings, and more. Boxed dinners are available with advance orders. For tickets or information, call the museum at (216) 231–1177 or (800) 317–9155, ext. 279; website, http://www.cmnh.org/.

MAY 18–20

Sky Tour 2001

South of Bellevue, Ohio. Hosted by the Huron Valley Astronomers Group and TECH2000. Registration deadline is May 11. Contact TECH2000, 69 South Ridge Street, Monroeville, OH 44847; (419) 546–2997; e-mail, tddi@accnorwalk.com; website, http://www.accnorwalk.com/~tddi/tech2000/skytour.

MAY 25

Shreveport Star Party

Ralph A. Worley Observatory, south of Shreveport, Louisiana. Contact Cran Lucas, (318) 797–1524; e-mail, clucas@softdisk.com; website, http://www.lsus.edu/nonprofit/sbas/.

MAY 25–28

Riverside Telescope Makers Conference

Camp Oakes, near Big Bear, California. For more information, contact (909) 980–6050; e-mail, rstephens@foxandstephens.com; website, http://www.rtmcinc.org/index.html.

MAY 26

Prairie Grass Stargaze

Jeffers Petroglyphs Historic Site, Bingham Lake, Minnesota. Contact Don Franck, e-mail, dfranck@aol.com, or Thomas Sanders, Jeffers Petroglyphs Historic Site, P.O. Box 118, Bingham Lake, MN 56118; e-mail, thomas.sanders@mnhs.org. A

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11:40am-12:40pm	Bob Berman "Mysteries for the New Millennium"
1:40pm-2:40pm	Gary Seronik, Sky & Telescope Magazine
3:00pm-4:00pm	Dr. H. John Wood, NASA
4:30pm-5:30pm	Dr. Alex Fillipenko, UC-Berkeley

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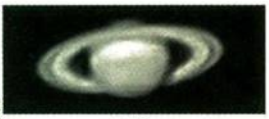

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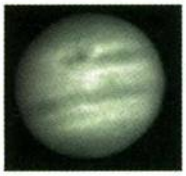

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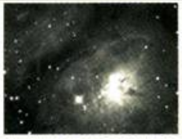

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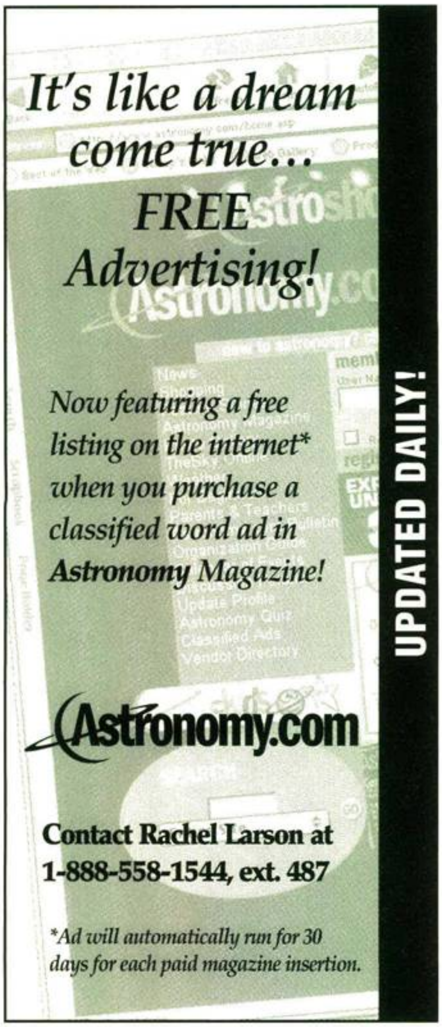

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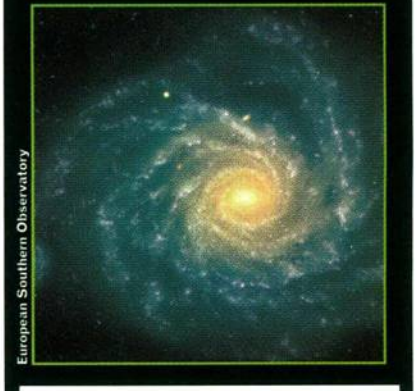
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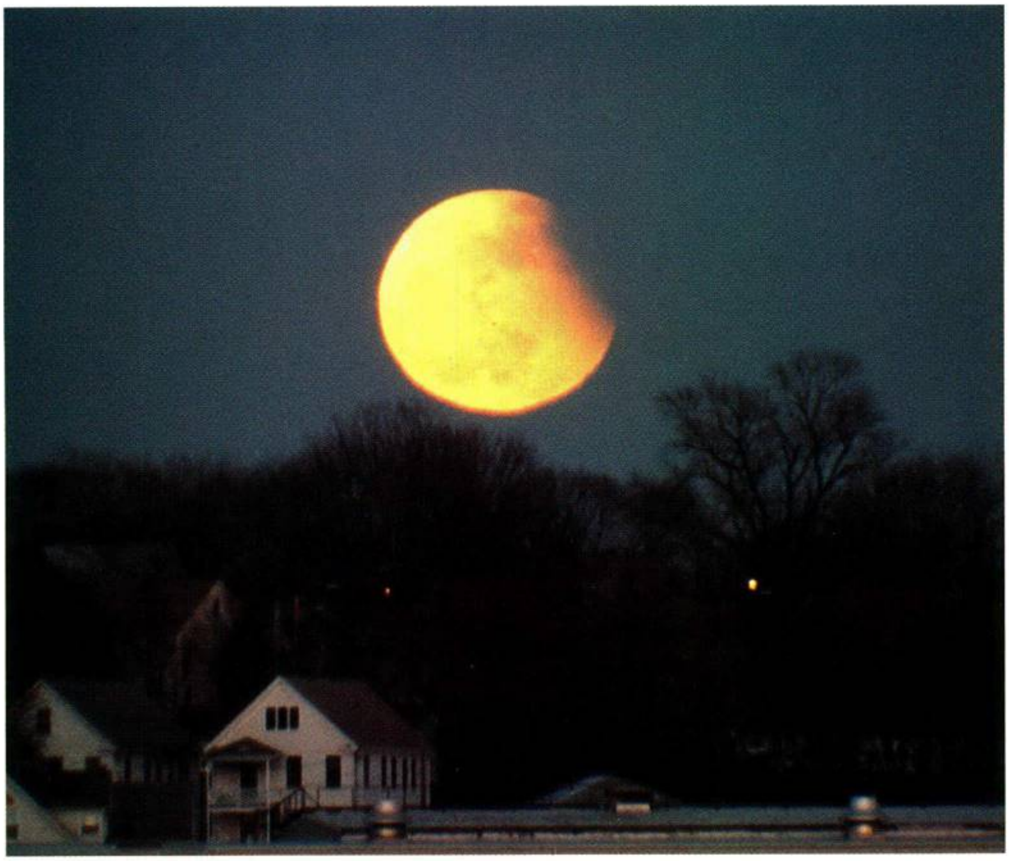
A Tale of Two Eclipses

▶An eclipse of the sun and one of the moon ended the millennium and carried in a new one as observers in North America, Europe, Asia, and Africa received stellar treats. On Christmas Day 2000, North Americans witnessed one of the best partial solar eclipses in years, with those in the country's mid and northern sections seeing more than 50 percent of the sun's disk blocked. On January 9 European, Asian, and African observers saw a ruddy lunar eclipse when Earth's shadow swept across the moon; in the United States and Canada, those along the northeastern seaboard caught the final portion of the umbral eclipse at moonrise.

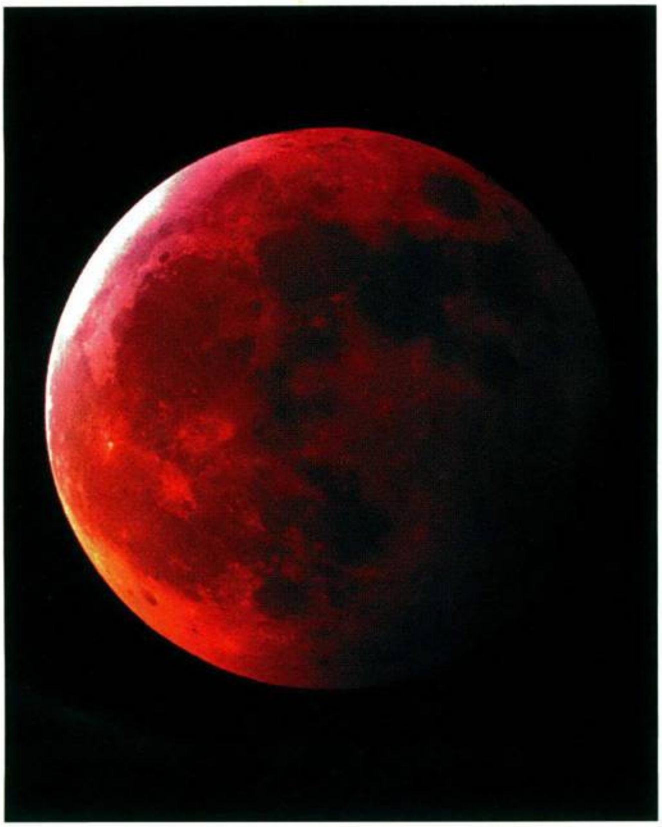
In Montreal, Canada, Jacques and Huguette Guertin were visiting relatives for Christmas when they viewed the solar eclipse. As luck had it, this offered one of the best areas from which to view the eclipse, weather permitting. The Guertins looked forward to a 61% coverage of the sun's disk at maximum eclipse. After Christmas lunch, Jacques threw on a sweater as mid-eclipse approached and went outside for a look. "Yow! Going from 80° F to –18° F was a shock," he says, "so I took a glimpse." Although moderate clouds flowed across the scene, Guertin saw a great view of the big bite out of the sun's disk. Improvising to project the eclipsed sun, he next



Lunar Eclipse over New England

JAMES R. DIRE

(3.5-inch Maksuotv-Cassegrain at f/5.6, Kodak Gold 100 film, taken January 9, 2001, from New London, Connecticut)



A Bronzed Moon

GIANNI TUMINO AND MELANIA PLUCHINOTTA

(10-inch SCT at f/5.6, Kodak Elite II 100 film, 10-second exposure taken January 9, 2001, from Ragusa, Italy) removed his belt and "observed five crescent suns projected onto my drooping pants." Because it was so cold, Guertin repaired to the indoors, only to repeat the process twice over the following half hour.

Shortly afterward, Guertin struck up a conversation with a brain surgeon and his wife who happened to be at the care facility where he had lunch. These normally stoic people, according to Guertin, "went nuts" when the eclipse began, projecting the sun's disk onto many surfaces in their kitchen — walls, floors, countertops, etc. — and enjoying a clear view from the comfort of indoors. Two new eclipse chasers were born; they are now interested in seeing the total solar eclipse in Australia in December 2002.

Half a world away, in Redditch, England, Matthew Boulton enjoyed observing the lunar eclipse.

"The orangy glow was easy to see with the naked eye," he says, "but with optical aid the view was even more magical. It was a beautiful sight and I was fortunate to get some memorable photos I will treasure forever." Eclipse fever, it seems, was everywhere this past winter.

Share Your Stories

Send your 500- to 800-word reports describing your observing experiences to:

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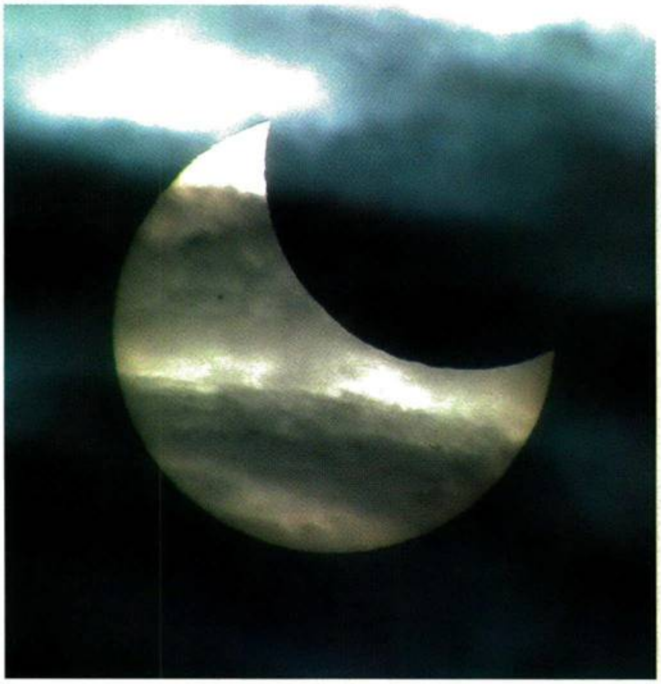
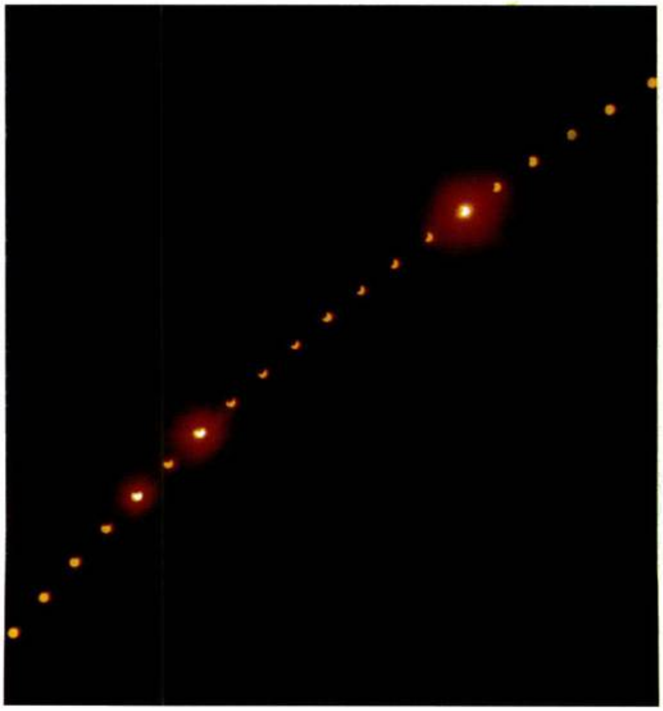


Solar Eclipse on Christmas

TOM WARNER

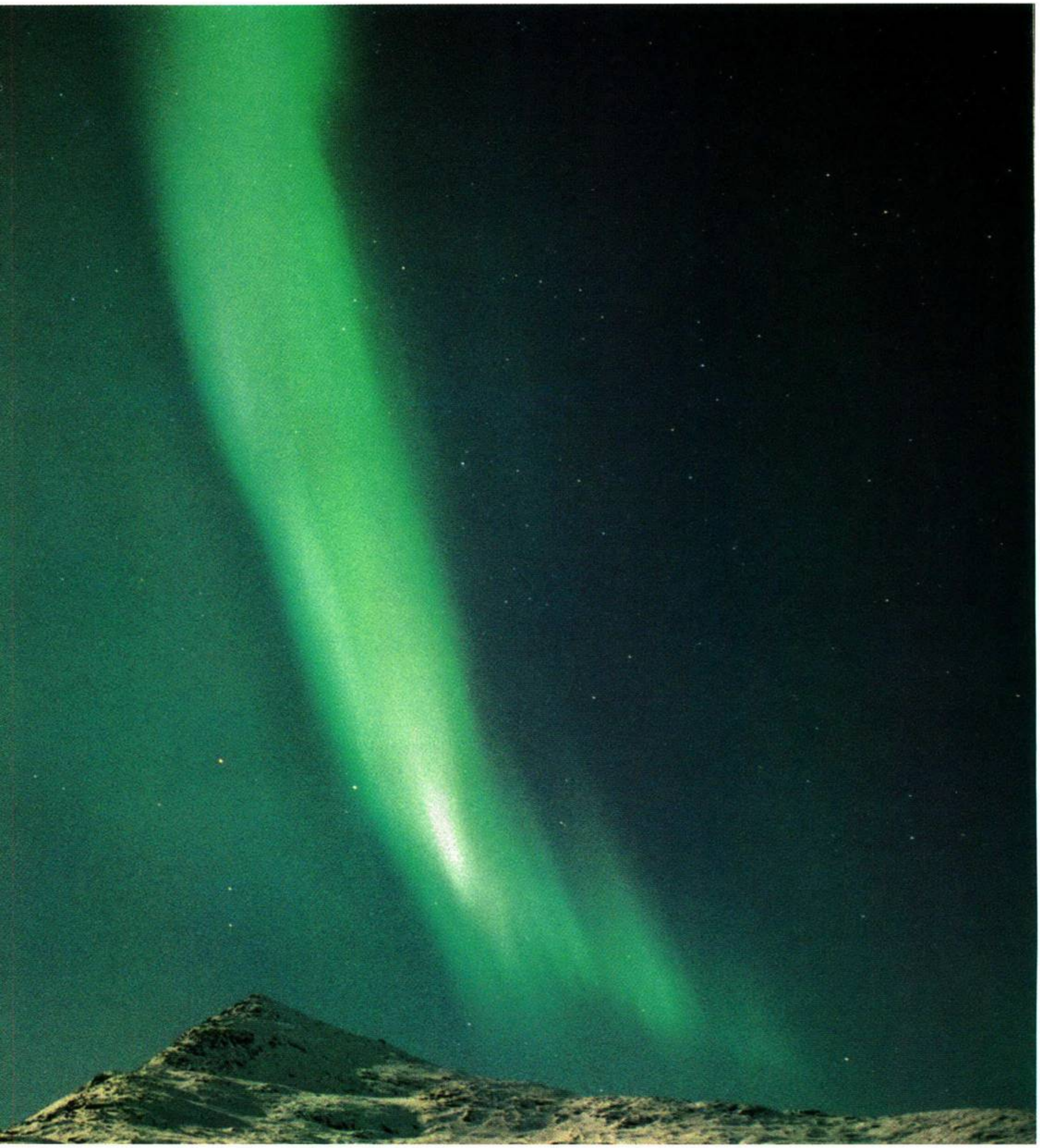
(2.8-inch f/6.8 refractor, Nikon Coolpix digital camera, 1/250-second exposure taken December 25, 2000, from Rapid City, South Dakota)



Eclipse Start to Finish

PHILIPP RAN

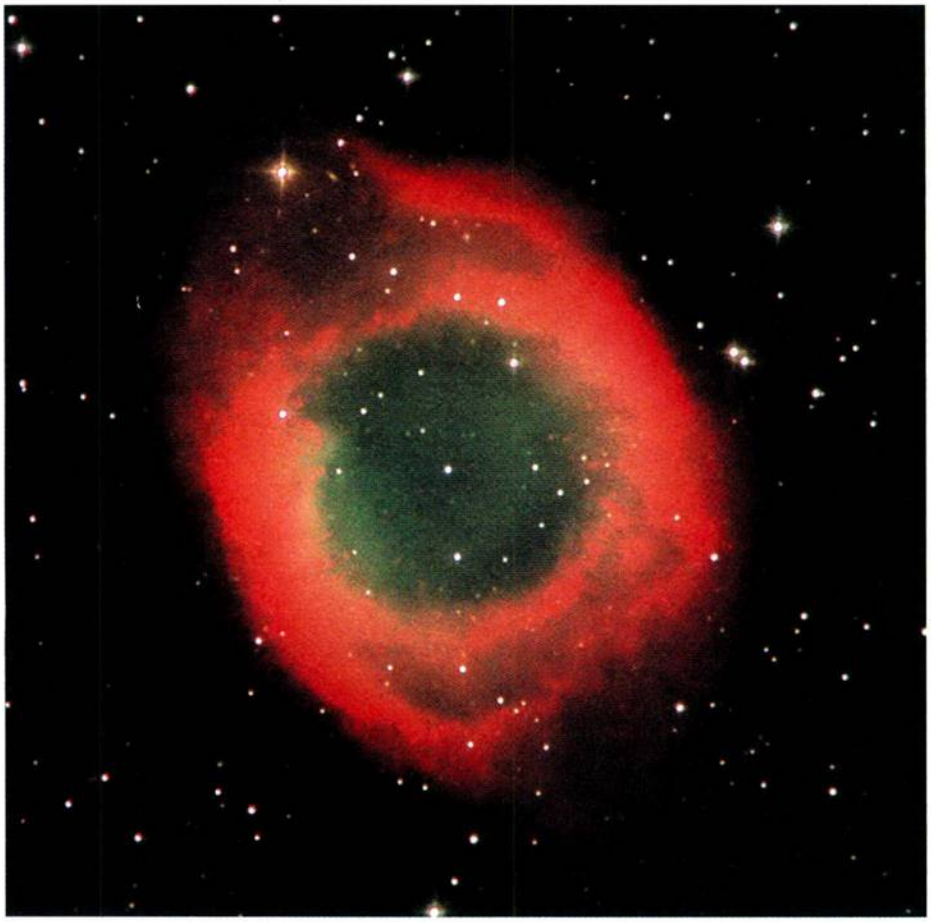
(85mm lens at f/22, Agfa 50 film, composite taken December 25, 2000)



Alaskan Spiked Aurora

MICHAEL KLENSCH

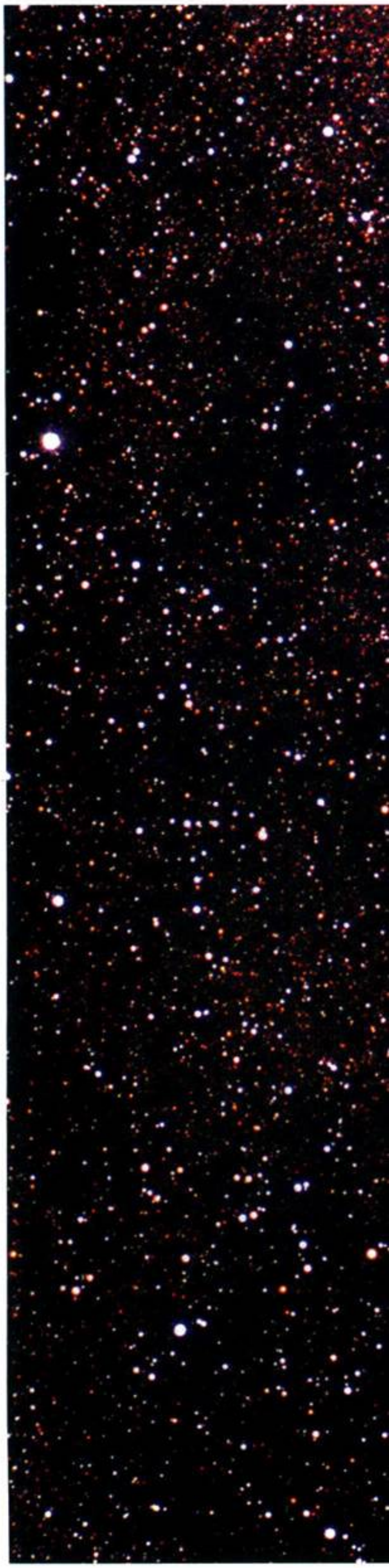
(24mm lens at f/2.8, Fuji Superia 200 film, 15-second exposure taken on November 10, 2000, from near White Pass along the Alaska/Canada border)

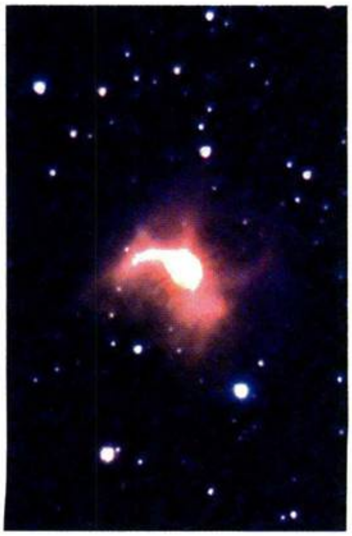


The Helix Nebula (NGC 7293) in Aquarius

CLIFF WRIGHT

(18.2-inch f/2.8 reflector, SBIG ST-8e CCD camera, composite of four exposures)

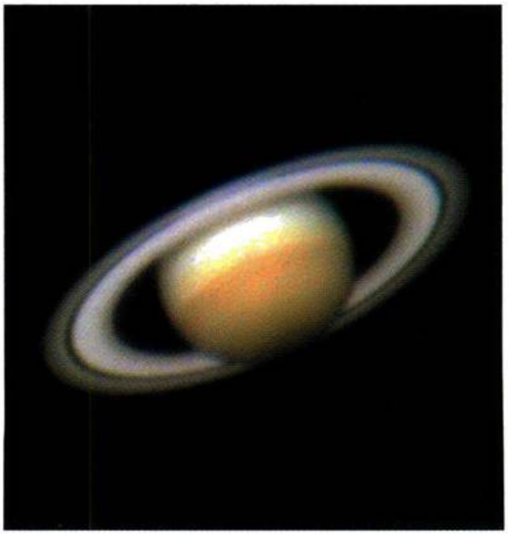




The Toby Jug Nebula (IC 2220)

JAMES R. FOSTER

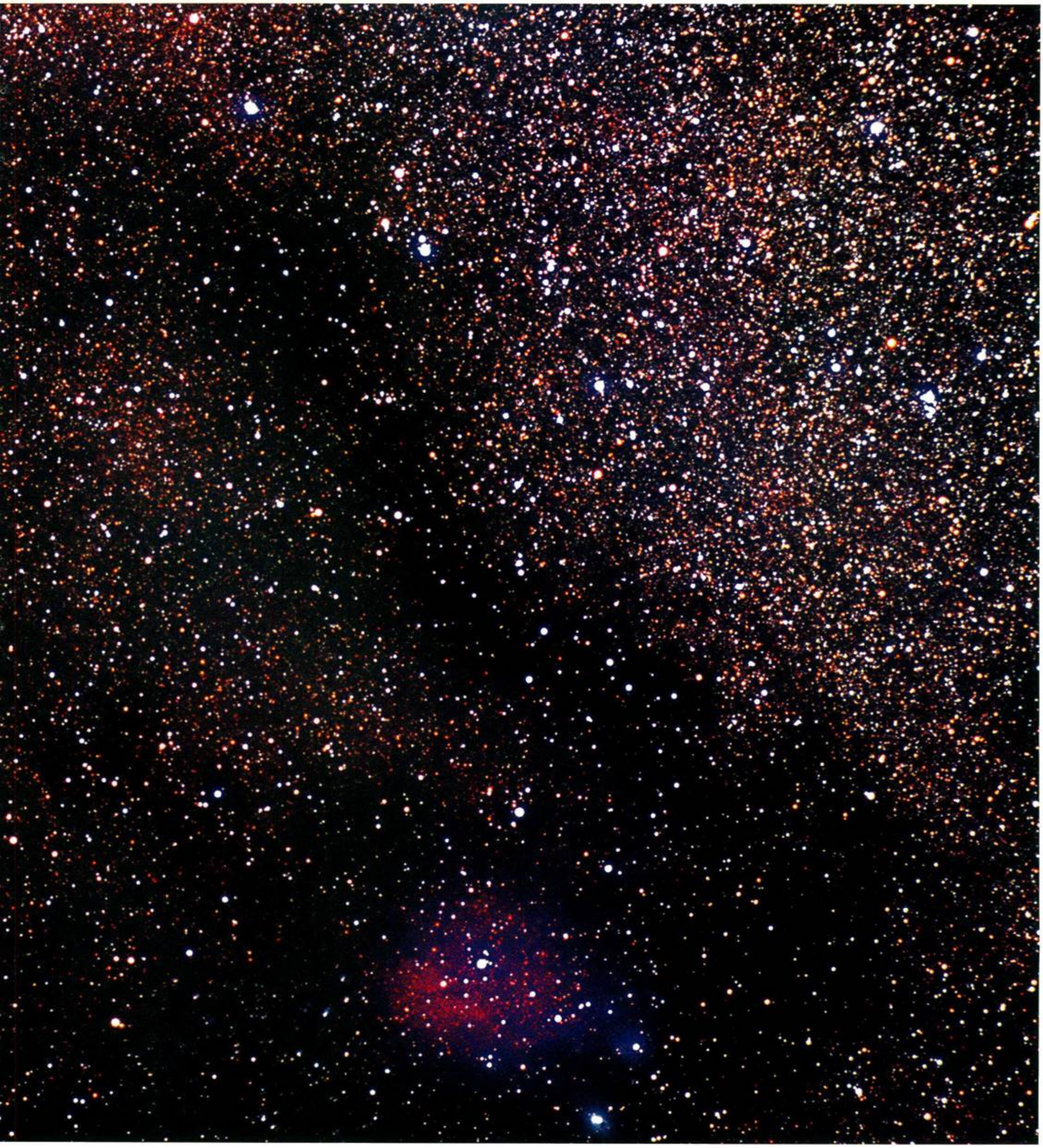
(11-inch SCT at f/20, hypered Fuji HG 400 film, composite of two exposures)



Saturn's Rings

ALLEN HWANG

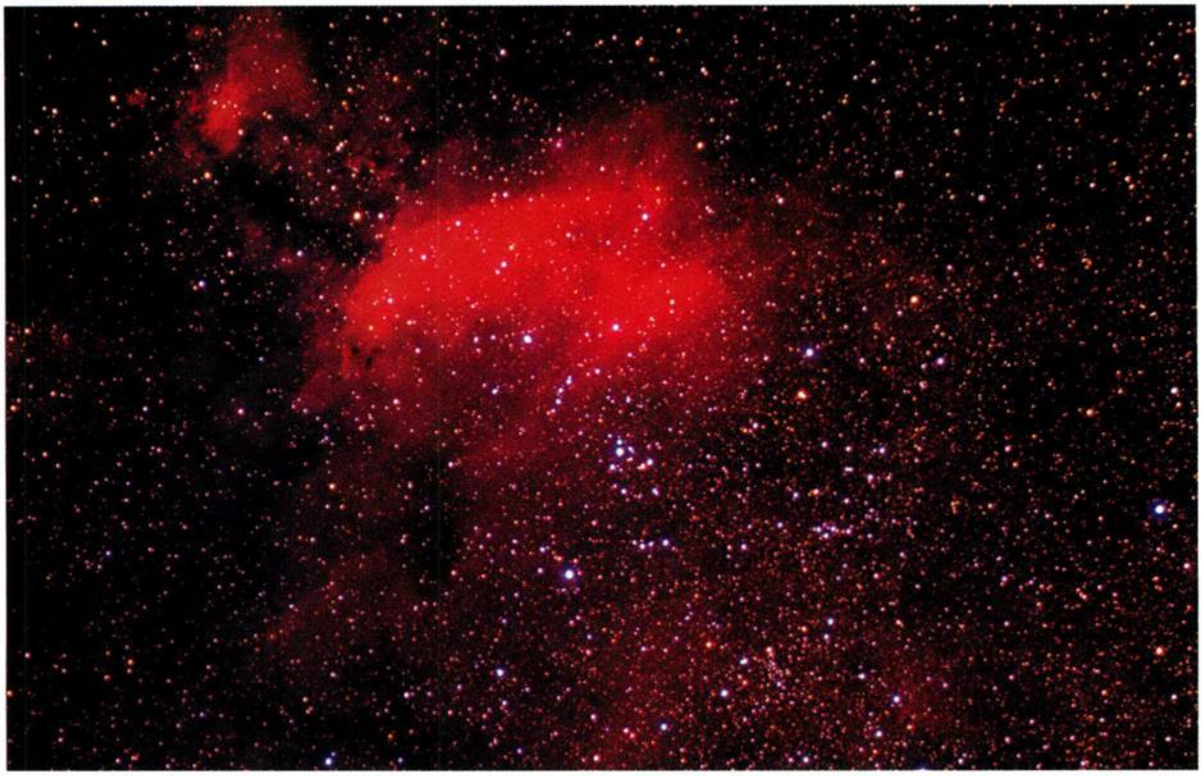
(60-inch reflector at Mt. Wilson, California, taken by aiming a Nikon Coolpix camera into the eyepiece on November 25, 2000)



Small Sagittarius Starcloud (M24)

JASON WARE

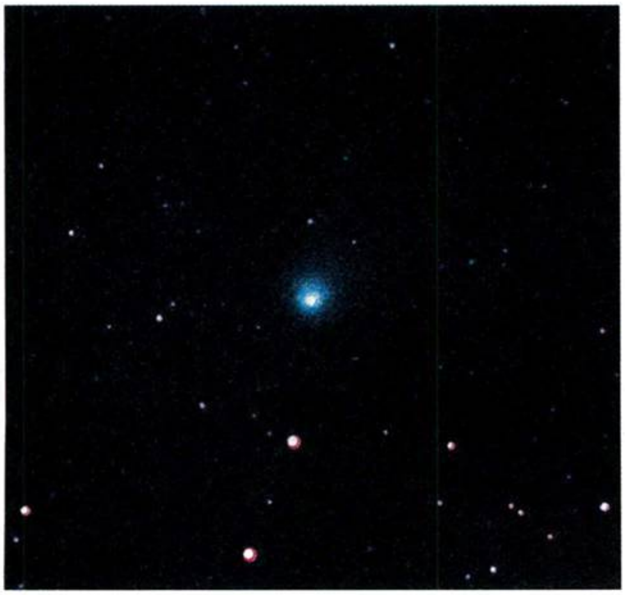
(6-inch f/9 refractor, hypered PPF 400 film, 120 format, composite of two 45-minute exposures)



Emission Nebula IC 4628 in Scorpius

JASON WARE

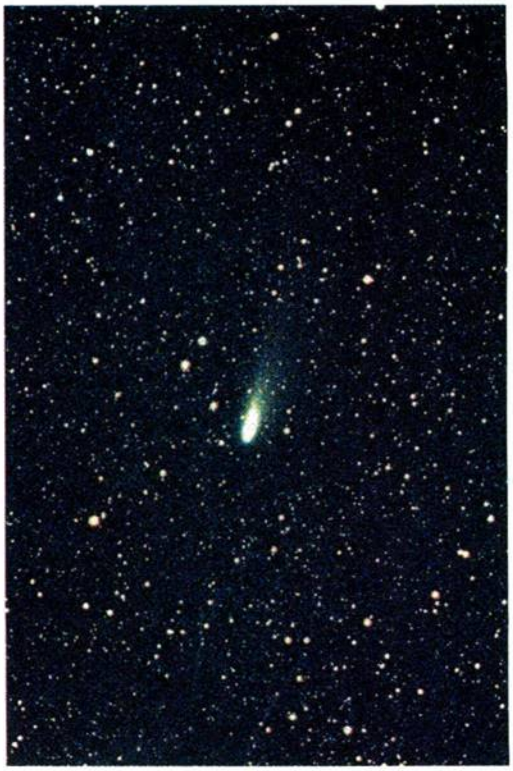
(6-inch f/9 refractor, hypered PPF 400 film, composite of two 45-minute exposures)



Comet McNaught-Hartley (C/1999 T1)

ALLEN HWANG

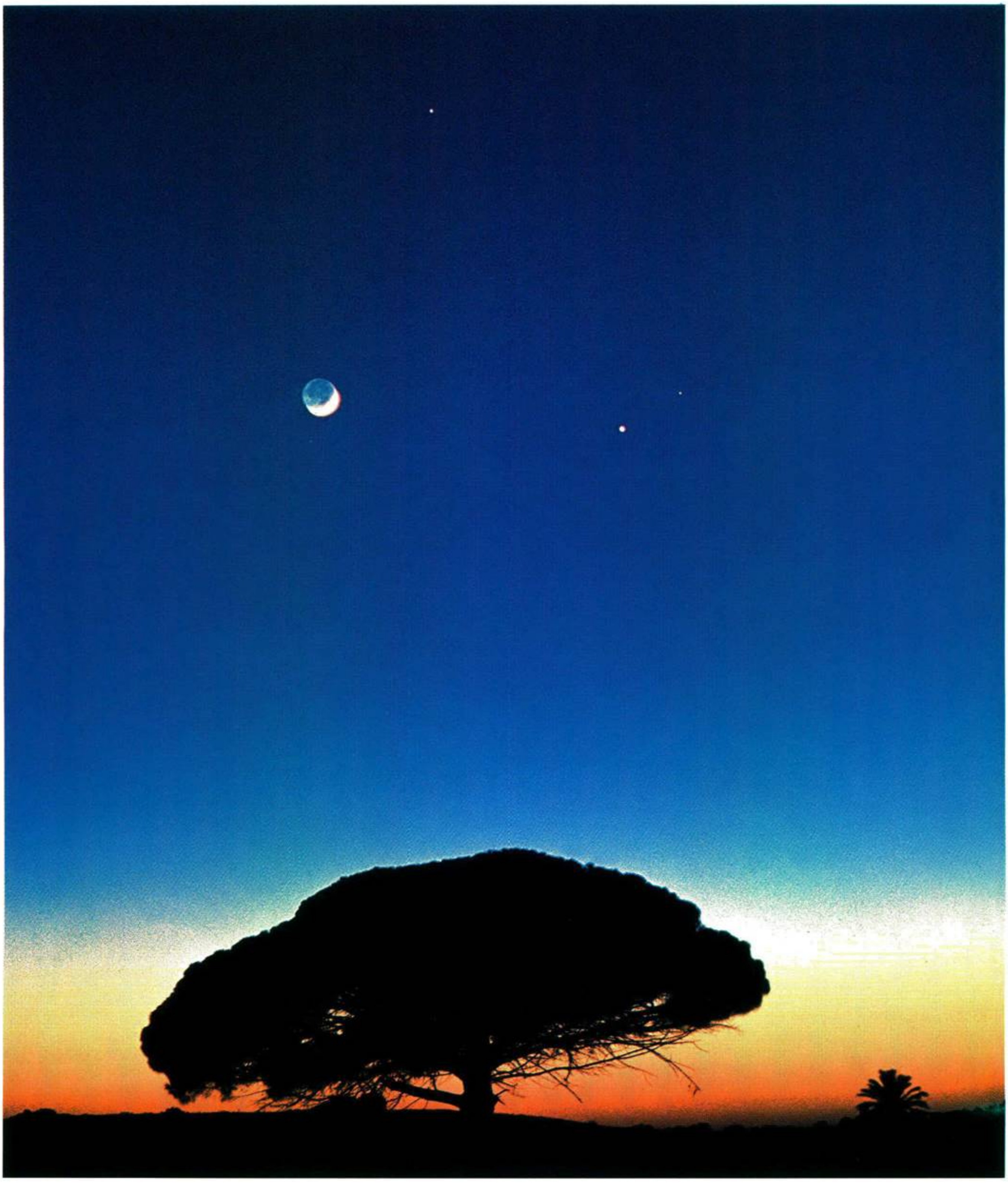
(6-inch refractor at f/7, Fuji Super G 800 Plus film, composite of 5- and 10-minute exposures taken January 3, 2001)



Comet LINEAR (C/1999 Y1)

ALBERTO LEVY

(4-inch f/5 refractor, Fuji NPH 400 film, 12-minute exposure taken July 2, 2000)

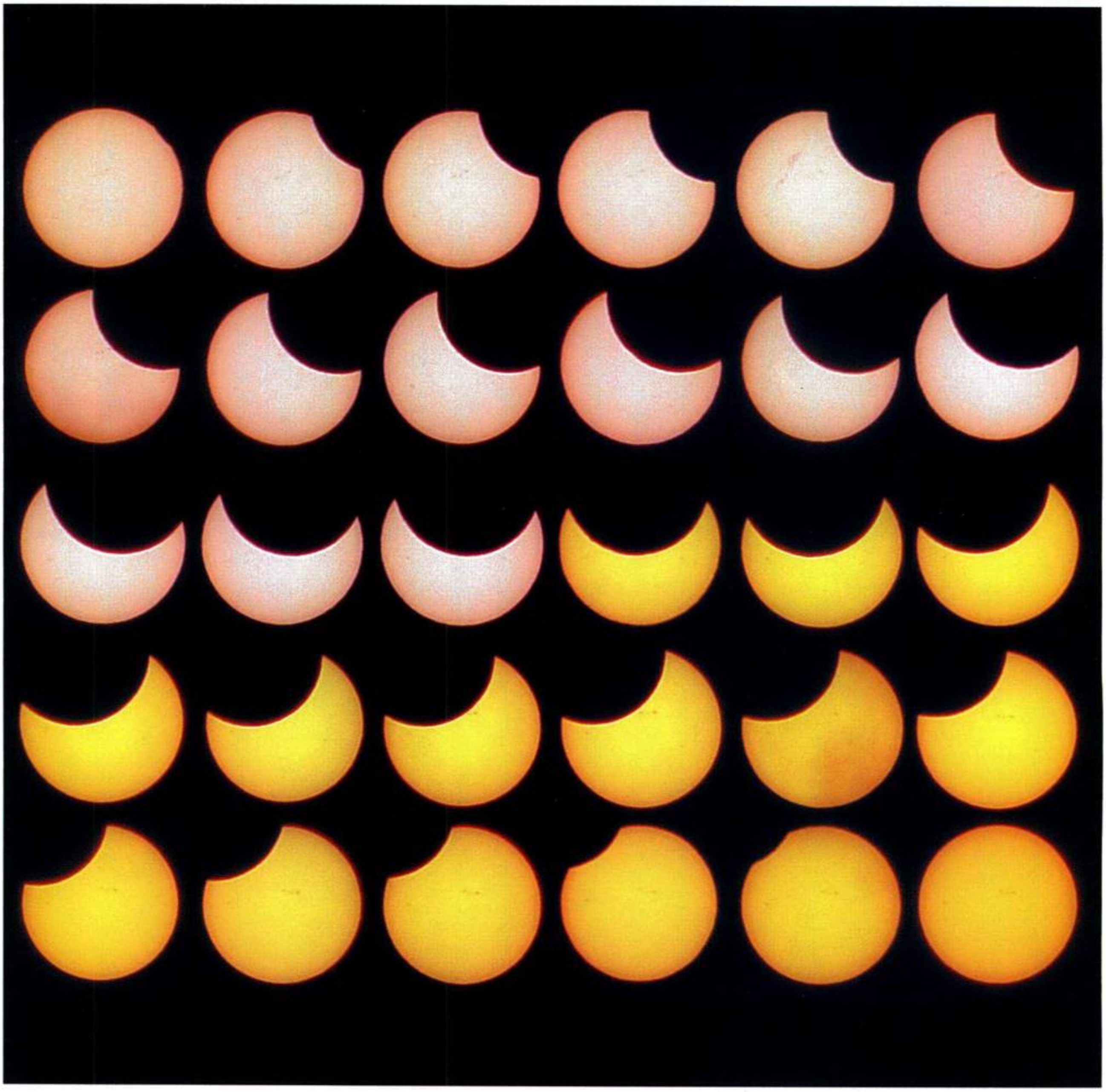


The Moon, Saturn, Jupiter, and Mars Together

GIANNI TUMINO AND MELANIA PLUCHINOTTA

(85mm lens at f/2.8, Kodak E100VS film, 8-second exposure taken April 6, 2000)

This month's best astrophoto



The Christmas Eclipse Snapshot

GREGORY GAGE

(Sony CD-1000 digital camera at f/2.8–3.5, composite of 1/500-second exposures taken December 25, 2000)

This start-to-finish imagery of the eclipse as seen from Mountaindale, New York, was created by using the solar filters from *Astronomy*'s January 2001 issue and taking exposures every 6 minutes. The exposure was decreased by one f/stop at mid-eclipse.

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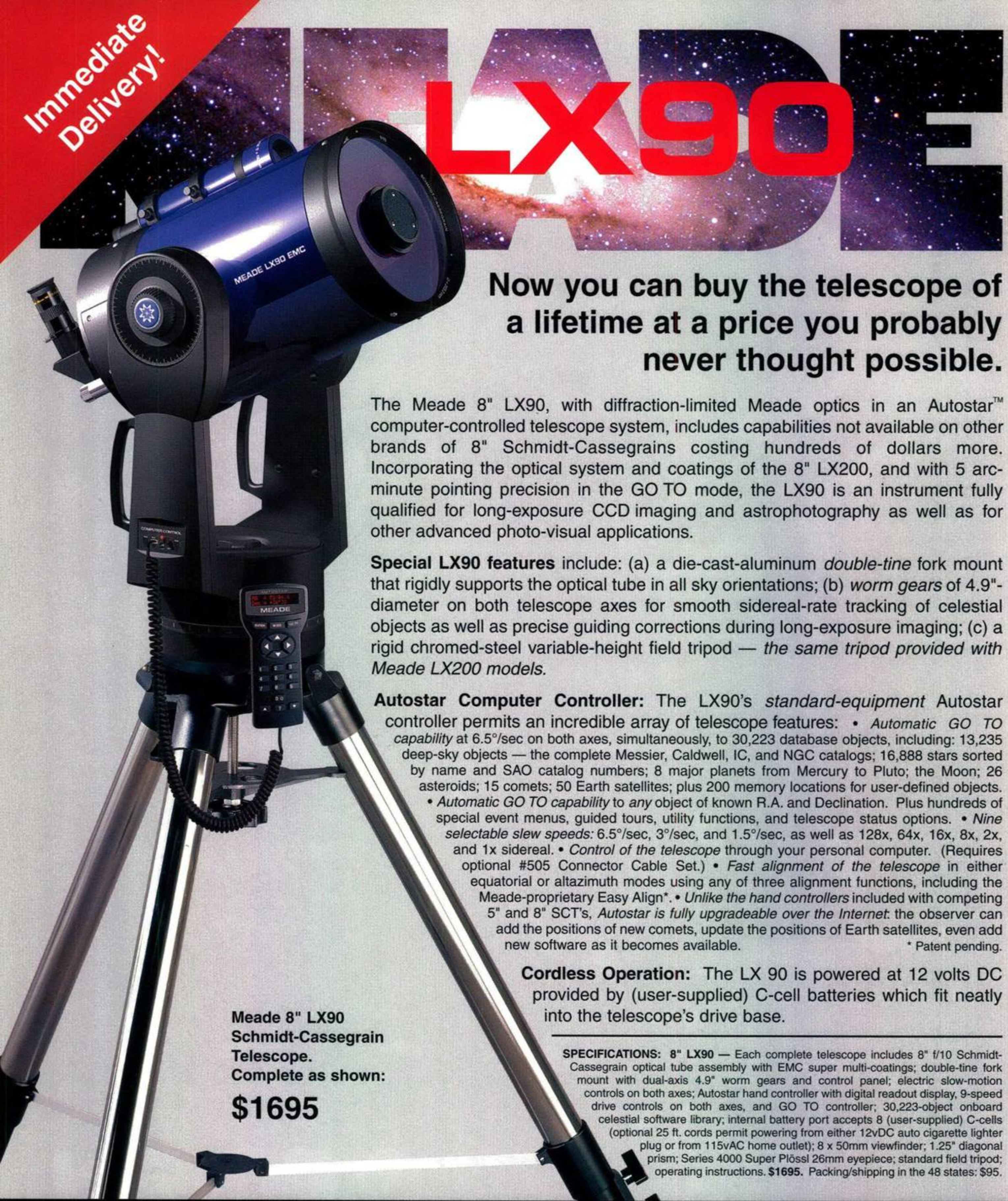

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